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SOME CYTOLOGICAL OBSERVATIONS ON PERIPHERAL MYELINATED NERVE FIBERS AS OBSERVED BY THE POLARIZED LIGHT METHOD

H. E. SETTERFIELD AND H. M. WEAVER,
Department of Anatomy, The Ohio State University

INTRODUCTION

Most neurological procedures depend upon the constancy of the artefacts produced by fixation and staining. Many observations have been made on living or freshly killed tissues with limited results. George St. de Renyi ('29), in particular, has studied nerve fibers by the microdissection method in an attempt to determine the actual cytological characteristics of the fiber while its protoplasm is in a living condition. His findings are of the greatest interest although his negative results in regard to certain structures leave the problem open to further investigation. In a previous paper of one of us (Setterfield and Sutton, '35) it was pointed out that we believe we approximate the observation of unaltered protoplasm by using the polarized light method. This technique has tended to demonstrate the existence in vivo of many of the cytological features which have been described by means of staining methods. It is our purpose in this paper to describe some of these structures as seen in polarized light and compare them with the same structures as they are usually described and illustrated in standard text books on the subject, notably Ramon y Cajal ('28) in his "Degeneration and Regeneration of the Nervous System," Volume one.

MATERIALS AND METHOD

The materials for this study are nerves from the brachial plexus, lumbo-sacral plexus and nerves from the lumbar area, from man, monkeys, dogs, cats, and rats suffering from various pathological

conditions. Normal nerves used for comparison were removed from healthy rats, cats, dogs, and monkeys. The source of the nerve trunk for each submitted photomicrograph is identified in its accompanying legend.

As the polarized light technique has been discussed in the paper previously cited, it is useless to do so here.

DISCUSSION

It may be objected that the structures described are not normal but the result of pathological changes. It is true that some of the structures observed are almost or quite invisible in the normal nerve fiber in polarized light; but this is equally true of many structures described by Cajal and others, as their cases were usually from animals following operative procedures and occurring in early stages of degeneration. In other words, our purpose is not to determine the normality of the structures in question but to try to identify them as artefacts or actual structures in the living nerve fiber. Furthermore, the study of nerve trunks removed from patients or from experimental animals suffering from pathological conditions secondarily affecting the peripheral nervous system is well adapted to this type of cytological study as the changes produced are more gradual and much less intensive. Also, since the nerve trunks have not been operatively cut the fibers remain in their own sheaths, thus eliminating the possibility of entrance of foreign material or the escape of protoplasm normally found in the fiber.

As has been pointed out in the paper cited above, swelling of the fibers with seemingly great increase in fluid content is the first and most striking early manifestation of disease in nerve fibers. This type of pathological change is essentially similar to cloudy swelling noted in all other portions of the body suffering from disease. So far as we have been able to determine this swelling does not alter the optical properties of the various parts of the fiber, merely serving to more clearly delimit details due to their greater size and separation from surrounding structures.

Attention was directed in another paper (Setterfield and Baird, '36) to the fact that the axis cylinder, sheath of Schwann, cementing disk, neurokeratin, and the incisures of Schmidt-Lantermann are isotropic in polarized light while the myelin itself is the only birefringent structure in the nerve fiber. We must now point out further that there are differences in the appearance of some of these structures when carefully examined. Specifically, the true axis cylinder (see below), in polarized light, is deep black at all points in the rotation of the stage of the microscope. On the other hand, the cementing disk, though isotropic (that is, not changing from black to white with rotation of the stage) is not as intense a black as the true axis cylinder. Similarly, the non-neurofibrillated portion of the axis cylinder (see below) is slightly less intensely black than the cementing disk, though unchanging during the rotation of the stage. In addition to these structures, still others show less intensities of blackness in the following order: neurokeratin (slightly degenerated), perineurium, bracelets of Nageotte, and the

sheath of Schwann. The perineurium is a brownish-gray at all points of stage rotation; the bracelets of Nageotte a medium gray, and the sheath of Schwann a pale gray. These intensities of blackness and whiteness are constant for the structure and are all indicative of isotropism which is manifested by the failure to change from black to white during the rotation of the stage. On the other hand, the myelin sheath, as the stage is rotated, changes from deep black to white four times in each revolution. It is the only anisotropic substance in the fiber. All the remainder are isotropic, but with varying degrees of blackness and whiteness to the eye and to the photographic plate.

In considering the nerve trunk as a whole it might be said in passing that the epineurium appears to be birefringent. Due to the contraction of its connective tissue fibers after death this birefringent appearance might be due to an optical phenomenon resulting from the passing of polarized light through this wavy tissue. Since it is not nervous tissue, it has not been the object of extended study.

Cajal ('28) stated that fixation of nerve trunks in formalin resulted in a shrinkage of the myelin sheath. An extended study was made by one of us (H. M. W.) on this phase of the problem. Nerves removed at cancellation were divided and one-half immediately frozen, sectioned and observed. The remaining half of the nerve trunk was allowed to remain in a fifteen per cent. aqueous solution of formalin for variable lengths of time, up to six weeks. Although it was impossible to obtain actual measurements it was felt that no shrinkage had occurred while in formalin. Due to the necessity of making thin sections the unfixed tissue so badly crumbled as to make photographic recording unsatisfactory.

Two semi-diagrammatic drawings have been included in this paper presenting in visual form the writers' conception of two physiological phases of nerve fibers of the peripheral nervous system. These drawings do not show exact quantitative differences in blackness and whiteness but have been exaggerated for purposes of illustration.

OBSERVATIONS

Bracelets of Nageotte (Fig. 1 and Drawing 1 and 2), as viewed in polarized light, seem to be paired cup-like structures with their bases approximating the cementing disk and their sides extending outward into the myelin sheath and a little nearer the sheath of Schwann than the axis cylinder. As to the origin of these structures the writers could not be sure, although it is possible that they represent an inward and upward reflection of the sheath of Schwann, at the level of the cementing disk. Most standard texts describe these structures as a ring of spines projecting away from the cementing disk. It would seem to the writers that this appearance might be due to either the wrinkling of this structure and the subsequent heavy deposition of staining material in the grooves, or to the fact that the nerve fiber has been cut in such a way that the top of the "cup" has been removed. Due to the diagonal cutting of a nerve fiber the bracelets here reproduced in Figure 1 show both these conditions.

The cementing disk (Fig. 2 and Drawings 1 and 2) is another

structure that is easily seen in polarized light, appearing as a transversely located plate into whose periphery runs the sheath of Schwann.

The sheath of Schwann (Fig. 6 and Drawings 1 and 2) has the same structural appearance in polarized light as in stained preparations. It is extremely thin, pale gray in color, and thickened slightly at the location of the nucleus of the Schwann cell and as the sheath approaches the node of Ranvier. Spherules of Erlholz could not be observed in the cytoplasm of the Schwann cell. Also the "dust" particles described by Swank and Davenport ('34) were invisible; indicating that the spherules of Erlholz and the "dust" particles do not exhibit the same optical properties as degenerating myelin, although their reaction to osmic acid is the same. The endocellular apparatus of Golgi likewise could not be seen. There are five possibilities regarding the relation of the sheath of Schwann with the cementing disk, none of which could be accurately determined with the neurological method under discussion.

1. The sheath of Schwann may be continuous over each cementing disk.
2. The sheath of Schwann may be contiguous with the substance of the cementing disk.
3. The sheath of Schwann may be reflected backwards, at the cementing disk, over the axis cylinder to form the sheath of Mauthner.
4. The sheath of Schwann may be reflected backwards, at the cementing disk, to form the bracelet of Nageotte.
5. The cementing disk may be formed by the fusing of the sheaths of Schwann from two adjacent internodal segments.

Due to our inability to differentiate the ending of the sheath of Schwann and the beginning of the cementing disk, and to a series of isolated observations during various stages of nerve fiber degeneration, the writers are inclined to favor the fifth hypothesis.

The sheath of Mauthner could not be identified in any fiber we have ever observed.

Myelin, in a normal nerve fiber (Fig. 2 and Drawings 1 and 2), is homogeneous and birefringent. As degeneration phenomena in the nerve fiber progress the myelin (Fig. 4) rapidly becomes isotropic as it changes into its degeneration products.

Neurokeratin (Fig. 3 and Drawings 1 and 2), in the normal nerve fiber, has an index of refraction which is only slightly different from the myelin. It seems, however, that its presence can be traced through the myelin, under oil immersion, as a thin, skeletal system of trabeculae. Therefore the writers feel that, in the normal condition, the very slightly granular appearance of the myelin is due to the presence of the neurokeratin framework. In rather early degenerating fibers this material swells and rapidly becomes black, (as seen in polarized light), thereby facilitating identification.

In the normal condition the axis cylinder (Drawing 2), as commonly referred to in the literature, is seen to be composed of two portions, (1) an inner cylindrical rod and (2) an outer enveloping sheath. The inner cylindrical rod, which we have called the true axis cylinder, is, in polarized light, isotropic, deep black, homogeneous, and of a uniform

calibre throughout the length of the nerve fiber. The outer enveloping sheath which Maximow ('34) calls the non-neurofibrillated portion of the axis cylinder is, in polarized light, isotropic but less intensely black than the true axis cylinder, thereby facilitating its identification. Practically every author has described the axis cylinder to be of constant calibre except at two points; an enlargement above and below, and a constriction as it passes through, the cementing disk. By reference to the included drawings it can be seen that it is the non-neurofibrillated portion of the axis cylinder only that is involved in this enlargement and constriction. It is generally assumed that the non-neurofibrillated portion of the axis cylinder is co-extensive with the true portion. In view of our observations on its relation to neurokeratin we have suspected that the non-neurofibrillated portion is related to the myelin segment rather than the true axis cylinder. While we cannot demonstrate conclusively that the non-fibrillated portion is interrupted at the cementing disc, our observations have cast doubt on the assumption of its continuity. At present we are unable to make a definite statement on the question.

In one physiological phase of the normal nerve fiber (Drawing 2) the incisures of Schmidt-Lantermann are extremely narrow with an index of refraction so nearly the same as myelin as to render them almost invisible.

In another phase the relation of the true axis cylinder, the non-neurofibrillated portion of the axis cylinder, and the incisures of Schmidt-Lantermann, is extensively altered. In this phase (Figs. 5, 6, 8 and Drawing 1) it can be seen that the true axis cylinder is, to all appearances, identical with that shown in Drawing 2 with the exception that there are areas which lie in direct contact with material which appears to be myelin. That this portion of the axis cylinder is the functional, and hence the true portion, has been clearly shown in work on anterior poliomyelitis, to be reported on in the future. Whenever fragmentation of the true axis cylinder was observed the animal always exhibited signs of paralysis.

One of the most interesting and, as yet, unexplained conditions in both early degenerating and physiological states of nerve fibers, is that the non-neurofibrillated portion of the axis cylinder seems to split at the level of the innermost part of an incisure of Schmidt-Lantermann. After this splitting it, to all appearances, slides upward and outward over the incisure of Schmidt-Lantermann until it comes into contact with the sheath of Schwann. That this sliding upward involves all of the non-neurofibrillated portion of the axis cylinder from one incisure to another is evidenced by a short area in which the true axis cylinder is in direct contact with myelin. By reference to the drawing it can be seen clearly that the so-called incisures of Schmidt-Lantermann (Figs. 5, 8, and Drawing 1), (which, in reality, are composed of an upward and outward extension of the non-neurofibrillated portion of the axis cylinder over the original incisural structure) together with their inferior prolongations (the non-neurofibrillated portion of the axis cylinder) form a true infundibulum ("funnel"). Through the tube and dilated mouth of the infundibulum is found extending the true axis

cylinder. The true axis cylinder can easily be likened to a stream of fluid running through several superimposed funnels.

The presence of neurofibrils is not doubted by most histologists. However, de Renyi ('29) reached the conclusion that there are no neurofibrils in the living nerve fiber of vertebrates he studied. Observations with polarized light have not settled this question to the satisfaction of the writers. In one notable example, illustrated in Figure 7, in a case twelve hours after cutting the nerve, structures were seen which one of us (H. E. S.) firmly believes to be neurofibrils. Up to the present time this is the only nerve studied at that particular length of time after operation and it may be that it is only at this or corresponding stage of degeneration that they are made visible by the swelling within the true axis cylinder and are not yet degenerated to the extent that their identity is lost. In all other cases, both normal and pathological, the true axis cylinder has shown a homogeneous structure throughout.

In a few cases we have been able to see axonal rings (Fig. 8) similar to those described by Cajal. They appear to be condensations of neurokeratin on the surface of the non-neurofibrillated portion of the axis cylinder, never on the true axis cylinder as above defined. They are quite variable in appearance and we do not believe they are present in normal fibers.

The authors wish to call attention in particular to the relation of the neurokeratin framework to the infundibulum and to the myelin. It appears that the neurokeratin, from its greatest concentration immediately surrounding the infundibulum (non-neurofibrillated portion of axis cylinder in some phases of nerve fibers), extends outward through the myelin to reach its minimum of concentration at its junction with the sheath of Schwann into which it seems to blend. This spongy neurokeratin framework contains potential cavities of varying size; potential because they are filled with true myelin.

CONCLUSIONS

1. Polarized light as a neurological technique depends upon the chemical structure and consequent optical properties of the materials observed. Certain lipoids, making up the substance of the myelin, have the property of birefringence while the chemical complex characterizing the other structures of the nerve fiber do not. This, together with a difference in the degree of isotropism of the non-birefringent structures, makes a study of individual structures both easy and accurate.

2. In this technique we believe that we possess a more sensitive, much simpler and more rapid method than any other now in use for the study of myelinated nerve fibers.

3. We have been able to describe in some detail the structure of nerve fibers, in so far as cytological characteristics are concerned. Our observations have tended to verify the existence

in vivo of several structures which some have suspected of being artefacts of staining and to deny the actuality of others described as characteristically present in nerve fibers.

4. Polarized light technique demonstrates the actuality in unstained nerve trunks of the sheath of Schwann, and its nucleus, perineurium, epineurium, myelin, neurokeratin, incisure of Schmidt-Lantermann, infundibulum, true axis cylinder and possibly its neurofibrils, non-neurofibrillar portion of the axis cylinder, cementing disk, bracelet of Nageotte, fissural, and axonal rings.

5. The polarized light method, according to our study, does not demonstrate the following structures: extra-fissural rings, sheath of Mauthner, spherules of Erlholz, "dust" particles, endocellular apparatus of Golgi, and apparatus of Golgi-Rezzonico.

6. We believe that the differences in intensities of blackness and whiteness of the various isotropic structures are due to a difference in thickness, chemical complex, or to a combination of both.

ACKNOWLEDGMENTS

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3. Dr. J. A. Toomey, of the Cleveland City Hospital, Cleveland, Ohio, for permitting us to use the photomicrograph of a nerve from a monkey suffering from anterior poliomyelitis.

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BIBLIOGRAPHY

Cajal, Ramon y. 1928. Degeneration and Regeneration of the Nervous System. Oxford University Press, London, Vol. I.

Maximow, Alexander A. and **Bloom, William.** 1934. Textbook of Histology. W. B. Saunders Company, Philadelphia.

Renyi, George St. de. 1929. The Structure of Cells as revealed by Microdissection. II. The Physical Properties of the Living Axis Cylinder in the Myelinated Nerve Fiber of the Frog. Journal of Comparative Neurology, Vol. 47, No. 3, pp. 405–425.

1929. The Structure of Cells as revealed by Microdissection. III. Observations on the Sheaths of Myelinated Nerve Fibers of the Frog. Journal of Comparative Neurology, Vol. 48, No. 2, pp. 293–310.

1929. The Structure of Cells as revealed by Microdissection. IV. Observations on Neurofibrils in the Living Nervous Tissue of the Lobster (Homarus americanus). Journal of Comparative Neurology, Vol. 48, No. 3, pp. 441–457.

Setterfield, H. E. and **Baird, T. T.** 1936. The Polarized Light Technique: A Comparison with the Marchi Method. Stain Technology, Vol. 11, No. 2, pp. 41–44.

Setterfield, H. E. and **Sutton, T. S.** 1935. Use of Polarized Light in the study of Myelin Degeneration. I. The Appearance and Progress of Degeneration after Transection of the Sciatic Nerve of the White Rat. Anatomical Record, Vol. 61, No. 4, and Supplement, pp. 397–411.

Swank, R. L. and **H. A. Davenport.** 1934. The Marchi Staining Method: Fixation. Stain Technology, Vol. 9, No. 4, p. 129.

EXPLANATION OF PLATES

Description of Plate I

Fig. 1. Median nerve of human removed at autopsy. Anatomical Diagnosis: attempted death by hanging; patient remained alive twenty-eight hours without regaining consciousness; edema and severe hyperemia of the lungs and brain. × 1000.

Fig. 2. Median nerve of young monkey removed under ether anesthesia. Anatomical Diagnosis: Caseous tuberculosis of lower left lung. × 1800.

Fig. 3. Median nerve of human removed at autopsy. Anatomical Diagnosis: right ulcerative pulmonary tuberculosis; left caseous pulmonary tuberculosis. × 1000.

Figs. 4 and 5. Median nerve of human removed at autopsy. Anatomical Diagnosis: multiple infarcts of spleen, kidneys, and lungs; acute hemorrhagic gastritis; toxic splenomegalia; etc. × 1000.

Fig. 6. Sciatic nerve of cat removed under ether anesthesia following experimental starvation for two weeks. Anatomical Diagnosis: negative. × 1800.

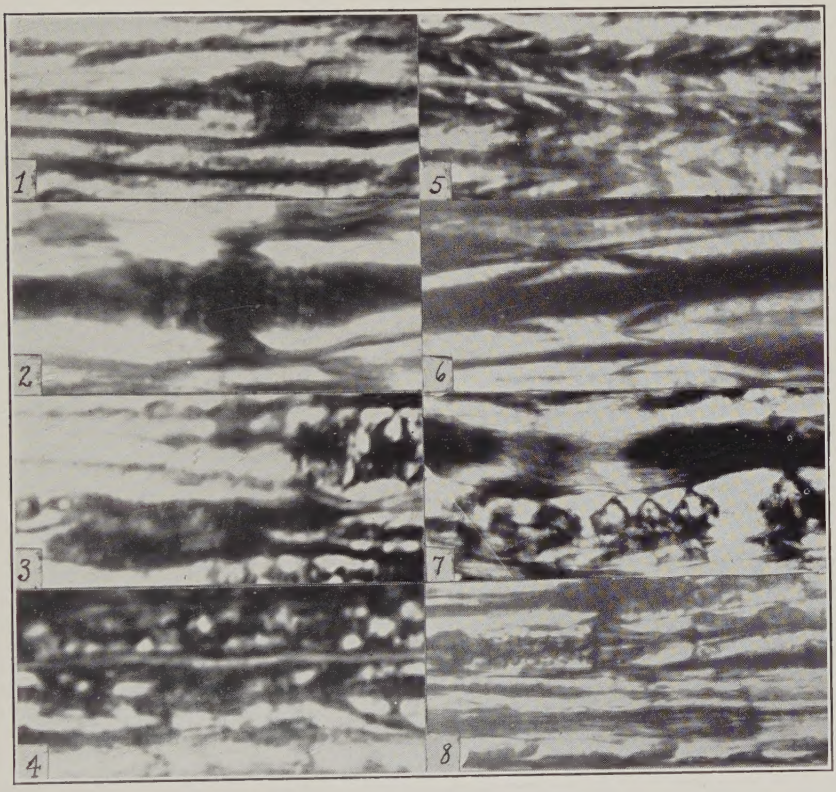
Fig. 7. Peripheral stump of sciatic nerve of an albino rat, twelve hours following surgical section. × 1000.

Fig. 8. Sciatic nerve of a young monkey showing paralysis of the leg for two days following experimentally produced anterior poliomyelitis. × 1000.

Explanation of Figures 1 and 2

Semi-diagrammatic drawings of two different physiological phases of a normal nerve fiber from the peripheral nervous system.

1. Non-neurofibrillated portion of the axis cylinder.
2. Sheath of Schwann.
3. True myelin.
4. Naked axis cylinder.
5. Infundibulum.
6. Neurokeratin trabecula.
7. Swollen part of non-neurofibrillated portion of axis cylinder.
8. Cementing disk.
9. Bracelet of Nageotte.
10. True axis cylinder.
11. Ostium of Infundibulum.
12. Nucleus of Schwann cell.
13. Incisure of Schmidt-Lantermann.
14. Infundibular ring.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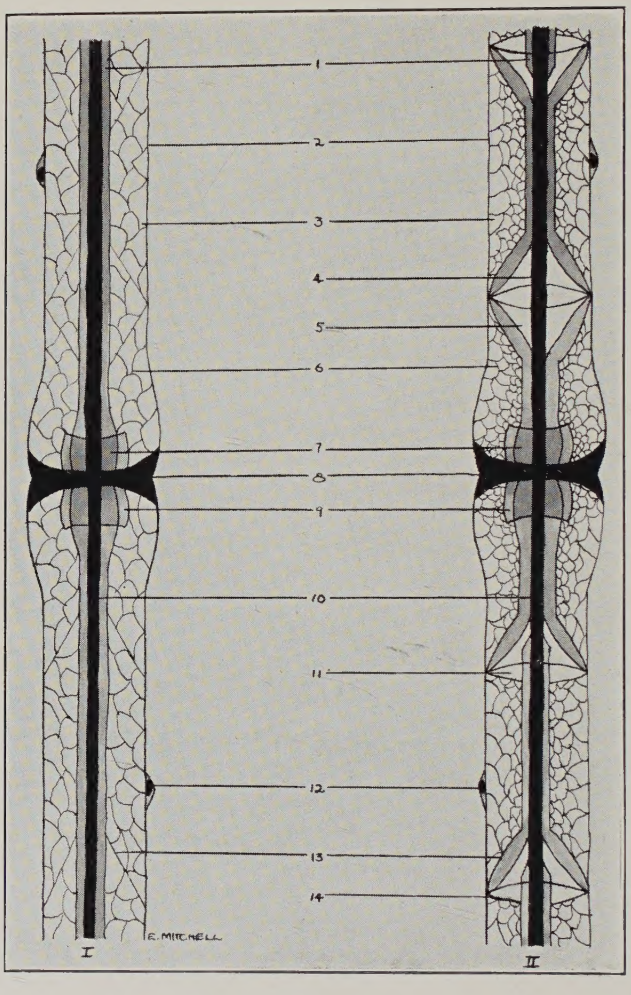
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E. MITCHELL
I
II

THE DETECTION OF SEX-LINKAGE IN FAMILIES COLLECTED AT RANDOM

CHAS. W. COTTERMAN
Genetics Laboratory, Ohio State University

For the genetic study of human characters two methods of collecting families are generally employed. If the character is quite rare the practice of studying only families containing at least one affected child is advisable. The small additional amount of information to be gained through the inclusion of families lacking affected members can in no way compensate for the greatly increased expenditure of time and effort. The method has a distinct advantage over that of random collection of families, since for the simpler types of hereditary behavior it will often be true that only one genotypic combination in the parents can produce affected children, in which cases the estimation of gene frequency and the necessary assumption of an equilibrium population are not required. Where the incidence of the trait is sufficiently high, on the other hand, a random collection of families in which the constitution of the families is disregarded will be found profitable. Moreover, for characters which are not readily recognized or generally reported, or those in which a special test is required, as in blood reactions and taste tests, a random collection cannot well be avoided.

Methods for the analysis of sex-linkage in families selected because at least one child is affected have been given by Hogben (1932), whereas an analysis applicable to randomly collected families has not yet been presented. An additional criterion for sex-linkage, however, has been suggested by Snyder (1934b), who shows that from a random survey of a population, separate estimates of the frequency of the sex-linked recessive gene may be gotten from the proportion of affected males and from the proportion of affected females, the test consisting in a comparison of the two statistics so obtained.

With respect to a sex-linked recessive character the expected proportions of affected sons and affected daughters among children of the various family types are easily deduced in terms of the frequency of the sex-linked recessive gene, q. Where these proportions are dependent upon q, the proportion expected in each case is found by application of the principle of random mating to be $q/1+q$. Designating this proportion by ζ for the

sake of simplicity, the offspring proportions for the four family types are as shown in Table I.

TABLE I

Type of Family	Expected Proportion of Affected Individuals	
	Among Sons	Among Daughters
i. Both parents normal	ζ	0
ii. Father only affected	ζ	ζ
iii. Mother only affected	1	0
iv. Both parents affected	1	1

The estimate of ζ is obtained from the observed frequencies of affected males and affected females in the general population from which the families are drawn. In a population at equilibrium with respect to the distribution of a sex-linked pair of alleles the proportions of normal and affected males are (1—q) and q, respectively, while for the females the proportions are ($1-q^2$) normal and q^2 affected females. Indicating the observed proportions in these classes by A, B, C, and D, respectively, and replacing q by $\zeta/1-\zeta$, we have the following equations of estimation:

$$A=1-2\zeta/1-\zeta,\ B=\zeta/1-\zeta,\ C=1-2\zeta(1-\zeta)^2,\text{ and } D=\zeta^2/(1-\zeta)^2 \ldots (1)$$

The probability of observing α normal and β affected individuals in a sample of N_1 males and of observing γ normal and δ affected individuals in a sample of N_2 females may therefore be written

$$P=\frac{N_1!N_2!}{\alpha!\beta!\gamma!\delta!}\left(\frac{1-2\zeta}{1-\zeta}\right)^{\alpha}\left(\frac{\zeta}{1-\zeta}\right)^{\beta}\left(\frac{1-2\zeta}{(1-\zeta)^2}\right)^{\gamma}\left(\frac{\zeta^2}{(1-\zeta)^2}\right)^{\delta}, \ldots\ldots (2)$$

$$\text{or}\quad L=\log P=\log N_1!\,N_2!/\alpha!\,\beta!\,\gamma!\,\delta! + (\alpha+\gamma)\log(1-2\zeta) + (\beta+2\delta)\log\zeta-(\alpha+\beta+2\gamma+2\delta)\log(1-\zeta)\ldots\ldots (3)$$

The optimum estimate of ζ from the observed N_1+N_2 individuals is obtained by employing Fisher's (1921) Method of Maximum Likelihood, which consists in finding the value of ζ for which L is maximum. Setting

$$\frac{dL}{d\zeta}=\frac{\alpha+\beta+2\gamma+2\delta}{1-\zeta}+\frac{\beta+2\delta}{\zeta}-\frac{2(\alpha+\gamma)}{1-2\zeta}=0\ldots\ldots\ldots\ldots\ldots (4)$$

leads to a quadratic equation of which the positive root is the maximum likelihood estimate,

$$(\zeta)_1 = \frac{\sqrt{(\alpha+2\beta+4\delta)^2+8\gamma(\beta+2\delta)} - (\alpha+2\beta+4\delta)}{4\gamma} \quad \ldots\ldots\ldots\ldots (5)$$

The notation (ζ) is used throughout this note to indicate a particular estimate of the parameter ζ. This function, (5), though somewhat laborious to calculate is nevertheless to be preferred over other estimates of ζ, since the invariance or reciprocal of the variance of this statistic, which is the amount of information respecting ζ elicited by the likelihood statistic in the observation of N_1+N_2 individuals, is never exceeded by that of any other estimate. This property of maximum likelihood statistics, which Fisher has termed "efficiency," is very readily demonstrated for this problem. The amount of information respecting any parameter, ζ, furnished by a sample of N_1+N_2 individuals is given by

$$I\zeta = S\left\{\frac{1}{m}\left(\frac{dm}{d\zeta}\right)^2\right\},$$

where m is the expected number in any class, the summation extending over all classes. The evaluation of this quantity for our problem may be presented in tabular form (Table II).

TABLE II

Expected Frequency, m	Differential coefficient, $dm/d\zeta$	$\frac{1}{m}\left(\frac{dm}{d\zeta}\right)^2$	
$N_1\frac{1-2\zeta}{1-\zeta}$	$-N_1\frac{1}{(1-\zeta)^2}$	$\frac{N_1}{(1-2\zeta)(1-\zeta)^3}$	$\frac{N_1}{\zeta(1-\zeta)^2(1-2\zeta)}$
$N_1\frac{\zeta}{1-\zeta}$	$N_1\frac{1}{(1-\zeta)^2}$	$\frac{N_1}{\zeta(1-\zeta)^3}$	
$N_2\frac{1-2\zeta}{(1-\zeta)^2}$	$-2N_2\frac{\zeta}{(1-\zeta)^3}$	$\frac{4N_2}{(1-2\zeta)(1-\zeta)^4}$	$\frac{4N_2}{(1-\zeta)^2(1-2\zeta)}$
$N_2\frac{\zeta^2}{(1-\zeta)^2}$	$2N_2\frac{\zeta}{(1-\zeta)^3}$	$\frac{4N_2}{(1-\zeta)^4}$	
N_1+N_2	0	$I\zeta = \frac{N_1+4N_2\zeta}{\zeta(1-\zeta)^2(1-2\zeta)}$	

This quantity is in fact the amount of information utilized by the likelihood estimate $(\zeta)_1$, the variance of which is therefore

$$V(\zeta)_1 = \frac{\zeta(1-\zeta)^2(1-2\zeta)}{N_1+4N_2\zeta} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Putting N_1 and N_2 each equal to unity, the amount of information provided by an observation of one male and one female is

$$i(\zeta)_1 = \frac{1+4\zeta}{\zeta(1-\zeta)^2\,(1-2\zeta)}.$$

Now from the observed proportions, A, B, C, and D, it is possible by employing the relations in (1) to invent innumerable estimates of ζ, and the sampling variance of each statistic, (ζ), may be derived by employing the formula,

$$\frac{1}{N}V(\zeta) = S\left\{w\left(\frac{\partial(\zeta)}{\partial\nu}\right)^2\right\} - \left(\frac{\partial(\zeta)}{\partial N}\right)^2,$$

in which w is the expected proportion in any class, and ν the observed number in that class. Each of the frequencies ν is replaced by the expectancy Nw after differentiation and the expressions for all classes are summed. By putting N_1 and N_2 each equal to unity in the reciprocal of the variance formula thus obtained we have the amount of information $i(\zeta)$ respecting ζ elicited by the estimate through the observation of one male and one female. By dividing the amount of information elicited by the amount available, $i(\zeta)_1$, we have the proportional amount of information utilized by the alternative statistic. This proportion is termed the relative efficiency of the estimate in question and may be designated by $E(\zeta)$. Below are listed some of these other estimates together with the corresponding values of $E(\zeta)$.

In estimating ζ we might utilize either the male proportions (A and B) or the female proportions (C and D) separately. Thus

$$(\zeta)_2 = \frac{B}{1+B} = \frac{\beta}{\alpha+2\beta}, \text{ and } E\,(\zeta)_2 = \frac{1}{1+4\zeta}.$$

$$(\zeta)_3 = \frac{\sqrt{D}}{1+\sqrt{D}} = \frac{\sqrt{\delta}}{\sqrt{\gamma+\delta}+\sqrt{\delta}}, \text{ and } E\,(\zeta)_3 = \frac{4}{1+4\zeta}.$$

The estimates $(\zeta)_2$ and $(\zeta)_3$ are based on males alone and on females alone. The effect of putting N_1 and N_2 equal to unity

is to make $i(\zeta)_2$ and $i(\zeta)_3$ represent the amount of information per male and the amount per female, respectively. These values are compared with $i(\zeta)_1$, the information furnished by two individuals, one male and one female. $E(\zeta)_2$ and $E(\zeta)_3$ therefore give the proportional amounts of information used when equal numbers of both sexes are available but where females and males, respectively are disregarded in obtaining the estimate of ζ.

By averaging the two estimates thus derived we might obtain a fourth statistic,

$$(\zeta)_4 = \frac{1}{2}\left(\frac{B}{1+B} + \frac{\sqrt{D}}{1+\sqrt{D}}\right) = \frac{\alpha\sqrt{\delta} + 3\beta\sqrt{\delta} + \beta\sqrt{\gamma+\delta}}{2(\alpha+2\beta)\,(\sqrt{\gamma+\delta}+\sqrt{\delta})},$$

$$\text{and } E\,(\zeta)_4 = \frac{16\zeta}{(1+4\zeta)^2}$$

Some other estimates and their efficiencies are

$$(\zeta)_5 = \frac{D(1-B)}{B(1-D)} = \frac{\alpha\delta}{\beta\gamma}, \text{ and } E\,(\zeta)_5 = \frac{\zeta(1-2\zeta)^2}{(1+4\zeta)\,(1-\zeta+\zeta^2)}.$$

$$(\zeta)_6 = \frac{B-D}{1-D} = \frac{\beta\gamma-\alpha\delta}{\gamma(\alpha+\beta)}, \text{ and } E\,(\zeta)_6 = \frac{(1-2\zeta)^2}{(1+\zeta)\,(1+4\zeta)}.$$

$$(\zeta)_7 = \frac{D}{B+D} = \frac{\delta(\alpha+\beta)}{\beta(\gamma+\delta)+\delta(\alpha+\beta)}, \text{ and } E\,(\zeta)_7 = \frac{1+\zeta}{1+4\zeta}.$$

The efficiency of each of the alternative estimates never exceeds unity and for many values of q the alternative estimates allow considerable loss of information. The values of the efficiencies of the alternative estimates in terms of per cent for values of q from 0 to 1 are shown in Figure 1.

SUMMARY

For a character attributable to a recessive autosomal gene substitution, the expected proportion of affected children among offspring of parents one of whom is affected is also $q/1+q$ or ζ, and the expected proportion of affected children among offspring of both normal parents is $(q/1+q)^2$ or ζ^2 (Snyder, 1934a). In terms of the gene-frequency, q, the proportion of affected individuals in the general population is the same as that for the female population with respect to a sex-linked recessive character and ζ is efficiently estimated as

$$(\zeta) = \sqrt{B'}\,/1+\sqrt{B'},$$

while

$$(\zeta^2) = B'/(1+\sqrt{B'})^2,$$

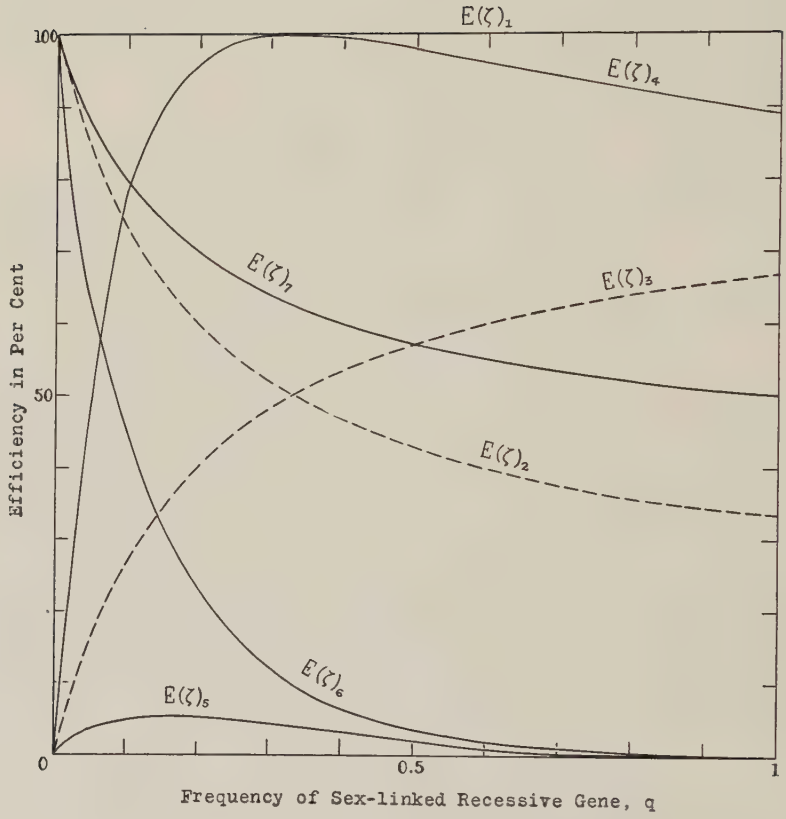

FIG. 1. The relative efficiencies of various estimates of the proportion ζ $(=q/1+q)$ for a sex-linked recessive gene substitution. The top line, $E(\zeta)_1$, indicates that the likelihood estimate uses the whole of the available amount of information for all values of q.

where B' is the observed proportion of affected individuals in the general population. The variance of these proportions, however, may be written in somewhat simpler form than the formulae given by Snyder. As is shown in Table II, the variance of ζ is

$$V(\zeta) = \frac{(1-2\zeta)\,(1-\zeta)^2}{4N},$$

in which N is the total number of individuals in the sample. The variance of ζ^2 is readily derived by means of the transformation formula,

$$I\zeta^2 = \left(\frac{d\zeta}{d\zeta^2}\right)^2 I\zeta = \frac{1}{4\zeta^2} I\zeta.$$

Hence $$V(\zeta^2) = 4\zeta^2 \,.\, V(\zeta).$$

Employing these formulae the values of $V(\zeta)/N$ and $V(\zeta^2)/N$ for values of B' from 0 to 1 might readily be added to the tables of ζ and ζ^2 already given by Snyder, thus further simplifying calculations.

For a sex-linked recessive character, ζ is the proportion of affected individuals to be expected among children of normal mothers and affected fathers as well as the expected proportion of affected sons where parents are both normal. The problem of estimating ζ for a sex-linked character is, however, a somewhat more difficult task arithmetically, the optimum estimate and its sampling variance being obtained by means of equations (5) and (6) of this note.

REFERENCES

Fisher, R. A. 1921. On the mathematical foundations of theoretical statistics. Philos. Trans. Royal Soc. London, A, 222: 309–368.

1935. Statistical Methods for Research Workers. Edinburgh. Oliver and Boyd.

Hogben, Lancelot. 1932. The genetic analysis of familial traits III. Matings involving one parent exhibiting a trait determined by a single gene substitution with special reference to sex-linked conditions. Jour. Genet. 25: 293–314.

Snyder, L. H. 1934a. Studies in human inheritance X. A table to determine the proportion of recessives to be expected in various matings involving a unit character. Genetics 19: 1–17.

1934b. Modern analysis of human pedigrees. Eugen. News 19: 61–69.

AN EXPERIMENT WITH HEAVY WATER

JOHN S. RICHARDSON
AND
G. RAYMOND HOOD[1]

In connection with a study of the chemistry of deuterium, we have had occasion in this laboratory to investigate the reaction of carbon dioxide on sodium carbonate dissolved in water containing 0.162% deuterium oxide. Possible reactions may be formulated as:[2]

1) $H_2O+D_2O+Na_2CO_3+CO_2 \longrightarrow NaHCO_3$ (preferentially)
2) $H_2O+D_2O+Na_2CO_3+CO_2 \longrightarrow NaDCO_3$ (preferentially)
3) $H_2O+H_2\mathbf{O}+Na_2CO_3+CO_2 \longrightarrow NaHCO_3$ (preferentially)
4) $H_2O+H_2\mathbf{O}+Na_2CO_3+CO_2 \longrightarrow NaHC\mathbf{O}_3$ (preferentially)

Equations (2) and (4) will yield a product which on thermal decomposition should give sodium carbonate, carbon dioxide, and a water of greater density than that taken for the synthesis of the bicarbonate; while a purely chance distribution of the light and heavy isotopes of hydrogen and oxygen, or a particular combination of equations (1) and (4), should result in a bicarbonate which would yield a water having the same density as that used for the synthesis.

EXPERIMENTAL

A sample of commercial "electrolytic water" containing 0.05% of deuterium oxide was further concentrated by electrolysis until its specific gravity with respect to ordinary water was 1.0001751 (at 25° C.), according to quadruplicate determinations made with two separately purified samples, and using two floats. Our float equilibrium temperatures were determined by the method of Emelius *et al.* (1)

A sample of 180 cc. of this water was saturated with anhydrous Na_2CO_3 (Merck Reagent) and placed in a closed reaction vessel agitated by rocking. Tank carbon dioxide was scrubbed with sulfuric acid, passed through glass wool, a tower of anhydrous magnesium perchlorate, and then over the sodium carbonate solution; the excess gas escaping to the atmosphere through another drying tower. Passage of the gas was continued for 48 hours. About 50 g. of $NaHCO_3$ precipitated and was separated by filtration; the precipitate was dried for 10 hours in vacuo over

[1]Contribution from the chemical laboratory of Miami University.
[2]The symbol **O** referring to the heavy isotope, O^{18}.

sulfuric acid; and then was decomposed by heating in a pyrex tube. It yielded 7.545 g. of water, weighed after purification by redistillation. As this was too small a sample for a density determination, it was mixed with 17.019 g. of ordinary water (previously thrice distilled) and the specific gravity of the mixture with respect to ordinary water was determined as 1.0000536 in duplicate determinations; the mixed sample being again redistilled between the two density measurements. Assuming that the volumes of the two water samples are additive, the density of the water recovered by decomposition of the bicarbonate must have had a specific gravity with respect to ordinary water of 1.0001829.

The filtrate from the precipitated bicarbonate was distilled from the residue remaining upon its evaporation, and twice redistilled; approximately 150 cc. was recovered after purification. Density determinations were then made upon it, using two floats; the sample was again distilled, and the density determinations were again carried out. The specific gravity with respect to ordinary water was 1.0001699.

The equilibrium temperatures for the floats used are recorded below, the temperatures being read from a Beckmann thermometer calibrated against a Centigrade thermometer certified by the Bureau of Standards.

Equilibrium temperature for Float:	No. I	No. II
Redistilled common water (Expt. 1)	24.539°	24.827°
" " " (Expt. 2)	24.538	24.828
Redistilled heavy water (Expt. 1)	25.220	25.503
" " " (Expt. 2)	25.218	25.506
Recovered filtrate water (Expt. 1)	25.198	25.481
" " " (Expt. 2)	25.198	25.490
Diluted water from $NaHCO_3$ (Expt. 1)	24.746	.....
" " " " (Expt. 2)	24.751	.....

These temperatures indicate that if the specific gravity of ordinary water is taken as unity at the equilibrium temperature, we have for:

	Specific gravity	% D_2O
Heavy water taken for the experiment	1.0001751	0.162
Heavy water recovered from filtrate	1.0001699	0.157
Heavy water recovered from bicarbonate	1.0001829	0.169

DISCUSSION

These experiments indicate that a slight concentration of deuterium or of a heavy oxygen isotope occurs in the formation of sodium bicarbonate. The probability is that **O** is concentrated, as Urey and Greiff (2) have recently shown the fractionation:

$$2\ H_2\mathbf{O} + CO_2 \longrightarrow 2\ H_2O + C\mathbf{O}_2$$

while from a consideration of the speed with which ionogen equilibria are established we should be led to expect a purely

chance distribution of $NaHCO_3$ and $NaDCO_3$ molecules; the concentration of $NaDCO_3$ being in direct ratio to the concentration of D_2O in the solution water.

REFERENCES CITED

(1) **Emelius, James, King, Pearson, Purcell, and Briscoe.** J. Chem. Soc., (1934), 1948.
(2) **Urey and Greiff.** J. Am. Chem. Soc., *57*, 321 (1935).

Matter

In this volume the authors have discussed, almost entirely from a classical point of view, a selected number of subjects of interest in modern physics. The acceleration due to gravity, elasticity, compressibility of solids and liquids, surface phenomena and kinetic theory are among the topics to receive a comprehensive theoretical treatment which is subsequently made use of in the discussion of related experiments. A very interesting section is Chapter X on osmotic pressure in which a discussion is contained of the Debye-Hückel theory of strong electrolytes.

While the discussions and derivations are complete and adequate, involved mathematics is not resorted to and the book should find a strong clientele among intermediate students. The book may be sincerely recommended and merits its place as one of the new Prentice-Hall series.—H. NIELSON.

Properties of Matter, by F. C. Champion and N. Davey. vii+287 pp. New York, Prentice-Hall, Inc., 1936. $4.50.

How We Came by Our Bodies

According to the author's statement in the introduction, this book is intended to increase the interest of the lay reader in reproduction, as well as to summarize some of the recent advances in the fields of Embryology and Genetics. The material is presented under three main headings: Part I, The Course of Development; Part II, The Machinery of Development; Part III, History of the Origin of the Machinery of Development.

Parts II and III present a very readable summary of the work of Genetics, though there is considerable doubt as to whether the average lay reader would get a very clear picture of the field. The cell and its chemical processes are summarized. The nature and activity of the gene are discussed. The effect of the cytoplasm in regulating development is reviewed, followed by a short discussion of histogenesis. Part II is concluded with a chapter on abnormalities of development. Part III is concerned with somewhat diverse topics. The possible derivation of the gene is traced through Bacteriophage, Virus, Bacterium, Yeast and Protozoan. A chapter is given to mutations in genes and the effect on the organism. A final chapter contains a bird's eye view of the evolutionary history of man and his possibilities in the future.

Part I, The Course of Development, summarizes the embryological development of the child. The treatment of this portion of the material, however, is so teleological that numerous erroneous impressions are left with the reader, viz., "And so, before the sperm cell enters the egg, the egg casts out the equivalent of what the sperm brings in." In another place this sentence is found, "This is all in accordance with the principle that the child develops with reference to future needs, and not with reference to current ones." Had the first six chapters (Part I) been omitted, the book would have been more acceptable.

The volume is profusely illustrated, though some of the plates are so technical that they could have little meaning for the average layman. The printing is excellent and the paper of good quality.—PAUL E. SCHAEFER.

How We Came by Our Bodies, by C. B. Davenport. xii+401 pp. New York, Henry Holt and Company, Inc., 1936. $3.00.

A STUDY OF THE LEECHES OF MICHIGAN

With Key to Orders, Suborders and Species

JOHN A. MILLER
Ohio State University

The leeches referred to in this study were collected in the state of Michigan in 1925, 1926, and 1927 by Dr. Y. Metzelaar and assistants of the University of Michigan. They were secured for study from the Museum of Zoology through the courtesy of Dr. Carl Hubbs of the University of Michigan and Dr. Raymond C. Osburn of the Ohio State University.

CONSPECTUS OF THE LEECHES OF MICHIGAN

Order 1. RHYNCHOBDELLA

Family Glossiphonidae

Genus *Glossiphonia*, Johnston, 1816.
Glossiphonia stagnalis (Linnaeus) 1758.
Glossiphonia complanata (Linnaeus) 1758.

Genus *Placobdella*, Blanchard, 1893.
Placobdella montifera Moore, 1912.
Placobdella parasitica (Say) 1824.
Placobdella picta (Verrill) 1872.
Placobdella rugosa (Verrill) 1874.

Order 2. ARHYNCHOBDELLA

Suborder 1. Gnathobdella

Family Hirudinidae

Genus *Macrobdella*, Verrill, 1872.
Macrobdella decora (Say) 1824.

Genus *Haemopis*, Savigny, 1874.
Haemopis marmoratis (Say) 1824.
Haemopis lateralis (Say) 1824.
Haemopis plumbeus Moore 1912.
Haemopis grandis (Verrill) 1874.

Suborder 2. Herpobdellida

Family Herpobdellidae

Genus *Herpobdella*, Blainville.
Herpobdella punctata (Leidy) 1870.

Genus *Dina*, Blanchard.
Dina fervida (Verrill) 1871.

Key to the Orders and Sub-Orders

Order 1. Rhynchobdella.

The mouth is a small pore in the anterior sucker, from which a muscular proboscis can be protruded and retracted. No jaws present. Two families, Glossiphonidae taken in this collection and Icthyobdellidae not found in this collection but previously reported in other collections. (1A to II in key).

Order 2. Arhynchobdella.

No proboscis present. This order includes two suborders:

Suborder 1. Gnathobdella.

A large mouth usually with toothed jaws, pharynx not forming a protrusible proboscis. This suborder includes one family, Hirudinidae (11 to 2A).

Suborder 2. Herpobdellida.

Mouth medium, not armed with true jaws. No gastric caeca. Habits predaceous. This suborder includes one family, Herpobdellidae (2A in key).

ARTIFICIAL KEY TO SPECIES IN COLLECTION

1. Mouth a small pore in the anterior sucker, from which a muscular probosis can be protruded; no jaws.
   1A. Complete somites essentially triannulate.
      1a. Eyes one pair, distinct, not contiguous in middle line. Genital pores separated by one annulus.
         1b. A conspicuous dark brown cuticular plate and gland on the dorsum. Color: Pale pink, grayish or brownish..... **Glossiphonia stagnalis**
      2a. Eyes in several pairs. Genital pores separated by two annuli.
         1b. Eyes in three pairs in nearly parallel rows. Seven pairs of gastric caeca. Nine pairs of testes. Body with a pair of dark longitudinal lines, above and below. Color: Brownish green with flecked dorsum. Body moderately thick and deeply pigmented, **Glossiphonia complanata**
      3a. Eyes one pair, compound. Seven pairs of branched gastric caeca. Side moderate to large.
         1b. Anterior somites widened to form discoid head.
            1c. Dorsum marked with three strongly papillated keels. Gastric caeca much branched. Color: Greenish brown, yellow marginal spots..... **Placobdella montifera**
         2b. Anterior somites not widened to form discoid head.
            1c. Body broad and flat, anterior sucker fused, posterior sucker free and distinct. Dorsal papillae few. Color: Pattern variable. Body green with yellow head, triangular reddish brown marginal spots, ventral surface striped..... **Placobdella parasitica**
            2c. Body smooth, much depressed, broad posteriorly, somewhat tapering anteriorly. Ocular region surrounded by triangular white area. Color: Dark brownish green, finely variegated with orange; a row of semicircular orange spots along the margin, **Placobdella picta**
            3c. Body much depressed. Dorsal papillae numerous, variable in conspicuousness, though usually rough and high. Median row forms a conspicuous interrupted line. Color: A mixture of browns, greens and yellows..... **Placobdella rugosa**

II. No proboscis. Mouth large, occupying entire cavity of the oral sucker.
   1A. Eyes five pairs on somites two to six, arranged in a submarginal arc. Genital ducts complex, muscular protrusible penis usually present. Testes paired, usually nine or ten pairs. Stomach provided with gastric caeca.

1a. Jaws prominent, teeth numerous, in one series, caeca along entire stomach.
1b. Genital orifices separated by five annuli. Dorsum with metameric, median red and marginal black spots.....**Macrobdella decora**
2a. Jaws small, provided with few teeth. Genital orifices separated by five annuli.
1b. Twelve to sixteen pairs of teeth on each jaw. Color: Variable, usually non-metamerically blotched with black..**Haemopis marmoratis**
2b. Twenty to twenty-five pairs of teeth on each jaw. Color: Uniform dark olive green, a dark median longitudinal stripe, a paler marginal stripe, often approaching a buff. Few or no blotches, **Haemopis lateralis**
3a. Jaws absent, no teeth present.
1b. Lip broad and flat. Few dorsal blotches or entirely wanting. No ventral blotches. Color: Uniform plumbeous or slaty-gray. Along the entire lateral margin there is a conspicuous rufous or orange band.....**Haemopis plumbeous**
2b. Lips thin, mouth moderate, caudal sucker round, broadly attached, slightly cupped. Male orifice at XI–b^5/b^6, female orifice at XII–b^5/b^6. Ovaries in somite XII. Size large, inhabits borders of bodies of water. Color: (Preserved) plumbeous, slaty black, no conspicuous marks. (According to Moore, protruded penis slender and straight, ground color paler than dorsal, dark blotches present), **Haemopis grandis**
2A. Eyes three or four pairs, not arranged in a regular arch. One or two pairs on somite two, and two pairs on the sides of the mouth on somite four. No jaws, no gastric caeca. Testes numerous, not paired. Predaceous.
1a. Eyes three pairs, first pair largest. Body elongate, sides nearly parallel. Color: Brownish gray, margin tinted red by lateral blood vessels. Rows of black spots arranged irregularly on dorsum, **Herpobdella punctata**
2a. Eyes usually three pairs. Body depressed posteriorly, rounded anteriorly. Large caudal sucker. Color: A dusky reddish brown, dorsum marked with double row of black spots. Genital pores separated by two annuli.....**Dina fervida**

RECORD OF DISTRIBUTION

Glossiphonia stagnalis (Linnaeus) 1758.
Flint Creek, Hubbs and Schultz, 1926.

Glossiphonia complanata (Linnaeus) 1758.
Osego Lake, Metzelaar, Aug. 23, 1925.
Hunt Creek, Metzelaar and Langlois, July 17, 1925.
Pool, Mecosshe Co., 7 mm. Metzelaar, June 11, 1925.
Sucker River, Luce Co., 81 mm. Metzelaar and Langlois, June 19, 1925.
Spectacle Lake, 6 mm. Metzelaar and Langlois, June 18, 1925.

Placobdella montifera Moore 1912.
Cheboygan Co., Indian River, 2 mm. Metzelaar and Langlois, June 14, 1925.

Placobdella parasitica (Say) 1824.
Dog Lake, Cheboygan Co., 3 mm. Metzelaar, August 12, 1925.
North Twin Lake, Cheboygan Co., 2 mm. Metzelaar and Langlois, August, 1925.
Raisin River, Langlois, May 12, 1927.
Stony Lake, Jackson Co., Metzelaar, June, 1926.
Long Lake, 2 mm. Metzelaar and Langlois, July 23, 1925.
*Pere Marquette River, Lake Co., 5 cm. (with 12 young), Metzelaar, March 15, 1925.
Dollar Pond, near Black River, Cheboygan Co., 3.5 cm. Metzelaar and Langlois, August 13, 1925.

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*Note the dates at which *Placobdella parasitica* was taken with young attached.

Placobdella parasitica [Continued]
Avery Lake, Thunder Bay River, drainage, Montmorency Co., 2.5 cm. Metzelaar and Langlois, July 8, 1925.
Newago Co., Langlois and Moody.
*S-Lake, Montmorency Co., 3 cm. with young, Metzelaar and Langlois, July 22, 1925.
Sucker River, Luce Co., 2.5 cm. Metzelaar and Langlois, June 19, 1925.

Placobdella picta (Verrill) 1872.
Bunners Creek, 1926.

Placobdella rugosa (Verrill) 1874.
Big South Branch, Pere Marquette, Newago Co., 2.8 mm. Metzelaar and Langlois, July 22, 1926.
Luce Co., Pike Lake Forest Reserve, Langlois and Metzelaar, June 18, 1925.
Valentine Lake, Montmorency Co., 1.5 mm. Metzelaar and Langlois, July 5, 1925.
Pickeral Creek, near P. Lake, Newaygo Co., 3 cm. with young, Langlois and Moody, July 7, 1926.
Bass Lake, Metzelaar, May 12, 1926.
Station 120, Metzelaar, 1925.
Newago Lake, Langlois and Moody.
Loockwood Lake, Montmorency Co., Langlois and Metzelaar, July 14, 1927.
Northern Tomohawk Lake, Montmorency Co., Metzelaar and Langlois, July 13, 1925.
S-Lake, Montmorency Co., 3 cm. Metzelaar and Langlois, July 22, 1925.
Sucker River, Luce Co., Metzelaar and Langlois, June 19, 1925.
Fremont Creek, 1.9 cm. Moody and Langlois.

Macrobdella decora (Say) 1824.
Thomas Lake, Osego Co., Metzelaar, 6 mm., August 24, 1925.
S-Lakes, N. W. of Gaylord, Osego Co., 5 cm. Metzelaar, Aug. 16, 1925.
Valentine Lake, Montmorency Co., July 5, 1925.

Haemopis marmoratis (Say) 1824.
Pike Lake, Forest Reserve, Luce Co., 4.5 cm. Metzelaar and Langlois, June 18, 1925.
Hagar Lake, Metzelaar and Langlois.
Muddy Creek (120) Metzelaar, 1925.
Head of Boardman Lake, Traverne Co., Metzelaar, May 13, 1925.
Cress Brook, Metzelaar, 1925.
Back Water, Muskegon River, Metzelaar.
Luce Co., 5.5 cm. Metzelaar, May 25, 1925.

Haemopis laterallis (Say) 1824.
Clam Creek, 6 cm. Metzelaar, May 13, 1926.
Creek in Kent Co., Metzelaar, 1927.

Haemopis plumbeous Moore 1912.
Vicinity of Perch Lake, Lake Superior Forest Reserve, Metzelaar and Langlois, June 15, 1925.
Lac Viene, Wisconsin and Michigan border, Metzelaar and Langlois.
Thunder Bay River (Bass Lake), Metzelaar.
Forest Reserve, Luce Co., Metzelaar and Langlois, June 18, 1925.

Haemopis grandis (Verrill) 1874.
Luce Co., Metzelaar, May 25, 1925.
Vicinity Perch Lake, Lake Superior Forest Reserve, Metzelaar and Langlois, June 15, 1925.
Muskegon drainage, Grant Township, 5 cm. Metzelaar, May 9, 1925.
Lake Superior Forest Reserve, 4 cm., June 15, 1925.
Balloger Creek, Metzelaar.
Forest Reserve, Luce Co., June 18, 1925.
Canada Creek, 4.5 cm., June 18, 1925.

Herpobdella punctata (Leidy) 1870.
Indian River, 3 mm. Langlois, June 14, 1925.
Luce Co., Metzelaar, May 25, 1925.
Bass Lake (Sta. 410), 6.5 cm. Metzelaar, May 22, 1926.

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*See note page 87.

Herpobdella punctata [Continued]
Dickerson Lake, Metzelaar and Langlois, Oct. 5, 1925.
Gull Lake, H. W. Fowler, 1925.
Tributary Maple Creek, Hubbs and Langlois, 1925.
Thunder Bay River (Bass Lake), Metzelaar and Langlois, 1925.
Pere Marquette River, Lake Co., Metzelaar.
Head Waters of Perch Lake, 5 cm. Metzelaar and Langlois.
Baker Creek, Neweygo Co., Langlois and Mosley, July 12, 1925.
Lake Co., Metzelaar, March 23, 1925.
Newaygo Co., 5 cm. Langlois and Mosley, July 10, 1926.
Lac Viene, Wisconsin and Michigan border, Metzelaar and Langois, Sept. 21, 1925.
Pere Marquette River, Metzelaar, 1925.
Dina Fervida (Verrill) 1871.
Creek Tributary to Pere Marquette River, Lake Co., Metzelaar, April 23, 1926.

The following list of species occurred in the collection taken from the state of Wisconsin:

Glossiphonia nepheloidae (Graff) 1899.
Lake 6 mi. S. W. of Dixon, Columbia Co., Green and Jones, Aug. 24, 1925.
Macrobdella decora (Say) 1824.
Wabekon Lake, Forest Co., H. T. Bolger, 6 cm.
Haemopis plumbeus Moore 1912.
Trout Stream, Riley Lake, Forest Co., 2.5 cm. H. T. Folger.
Haemopis grandis (Verrill) 1874.
Oconte and Rat River, Forest Co., 5 cm. H. T. Folger, Sept. 1, 1925.
Herpobdella punctata (Leidy) 1870.
Madelin Lake, Oneda Co., Metzelaar and Langois, Sept. 19, 1925.

CONCLUSION

In concluding this report I wish to state that this, though not complete, is a fair estimate of the leeches to be found in the State of Michigan. The leeches examined were in no essential features different from those found in other of the North, Central and Eastern States.

The leeches of this collection were, for the most part, in a coiled or contracted state making measurements mean but little. It was particularly evident from the collection that the Genus *Haemopis* was in abundance, four species being recorded. This may have been due to their large size and slow moving habits. It was interesting to note that *Placobdella parasitica* was carrying young as early as March 15th, and as late as July 22nd. This tends to substantiate the theory of a number of broods in a season.

A table of the known food habits of the leeches of Ohio is included in this report. There is reason to believe that the Michigan forms would follow essentially the same food habits as Ohio species.

The value of this study is in the knowledge it affords of the occurrence and distribution of Michigan leeches.

TABLE I

THE FOOD OF LEECHES OF OHIO

	Turtle	Fish	Snail	Aquatic annelid	Earthworm	Insect larvae	Organic debris	Mammals	Frogs	Scavengers
Glossiphonia stagnalis		x	x	x		x		x	x	x
Glossiphonia nepheloidea		x	x	x			x			x
Glossiphonia fusca		x	x	x		x				
Glossiphonia complanata			x	x						
Placobdella montifera		x	x					x	x	
Placobdella parasitica	x			x						
Placobdella rugosa	x		x							
Placobdella picta	Unknown									
Placobdella phalera	Unknown									
Actinobdella inequiannulata	Unknown									
Piscicola punctata		x								
Macrobdella decora	x	x		x				x	x	
Haemopis grandis			x	x	x	x	x			x
Haemopis marmoratis				x	x	x	x	x		x
Haemopis lateralis				x	x	x		x		
Haemopis plumbeus					x		x			
Herpobdella punctata			x	x		x		x	x	
Dina microstoma				x						
Dina fervida				x		x				

BIBLIOGRAPHY

Miller, John A. 1929. The leeches of Ohio. The Franz Theodore Stone Laboratory. The Ohio State University Press. Contribution No. 2.

Moore, J. Percy. 1898. The leeches of the National Museum. Proc. U. S. Nat. Mus., Vol. 21, pp. 543–563.

1901. The Hirudinea of Illinois. Bull. of State Lab. of Nat. Hist., Vol. 5, pp. 479–544.

1905. Hirudinea and Oligocheata Collected in the Great Lakes Region. Bull. of Fisheries, Vol. 25, pp. 155–165.

1912. The Leeches of Minnesota. Geol. and Nat. Hist. Survey of Minn., Zool. Series No. 5, 150 pages.

Verrill, A. E. 1874. Synopsis of the North American Fresh-water Leeches. Rep. U. S. Comm. of Fish and Fisheries for 1872–1873, pp. 660–689.

THE DAILY RATE OF GROWTH OF TOE NAILS

LINDEN F. EDWARDS[1] AND RALPH G. SCHOTT[2]
Ohio State University.

INTRODUCTION

It is generally known that nail growth is often retarded in acute infectious diseases, such as various fevers. However, no work has been published concerning the quantitative effect of disease and other nutritional disturbances, such for example, as pregnancy and hyperthyroidism, on the rate of nail growth. Such a study is now in progress and a prerequisite step to this project was the determination of the normal rate of nail growth in healthy individuals.

Several workers, notably Berthold ('50), Dufour ('72), Heller ('00), Voit ('30) and Sharpey-Schäfer ('30), have studied the rate of growth of finger nails and although different methods of measurement were employed it is generally agreed that normally the growth is on the average of one millimeter in ten days, that is 0.100 mm. daily. Results of observations made by the writers on the daily rate of finger nail growth in a great number of normal, healthy subjects agree in general with this figure. As regard the rate of toe nail growth, however, a review of the literature has failed to reveal any published data. Since the need for such information was felt in connection with the problem concerning the effect of disease on the rate of nail growth, accordingly research was started in an attempt to supply it. The object of this paper, therefore, is to report the results of observations made on the daily rate of toe nail growth in 70 apparently normal, healthy subjects of both sexes, ranging in age from 3 to 65 years.

It has been found by several of the above mentioned investigators that numerous factors affect the rate of growth of finger nails. Thus according to Berthold they grow more rapidly in summer than in winter, in children than in adults and slowest in old age; that normally those on the right hand grow more rapidly than those on the left and most rapidly on the longest fingers and slowest on the thumbs. In view of these findings of Berthold et al it was also decided to investigate some of these

[1]Dept. of Anatomy.
[2]Dept. of Zoölogy.

factors with respect to toe nails. The 70 subjects were therefore subdivided into groups according to sex (33 males and 37 females) and age. Age groupings were arbitrarily made; children (20) including those up to the age of 15 years; youths (30) those from 16 to 25 years, and adults (20) all those 26 years or older. Comparison of the mean rates of toe nail growth of these groups as well as those of the various toes was made in order to determine whether or not there is any significant variation. The technique of analysis of variance was applied to the sample as a means of procedure. This directly brings out the elements that may be contributing to disturbed homogeneity.

METHODS

A mark was made on each toe nail by means of a sharp, curved scalpel. In the case of the great toe nails the mark was made at the distal central convex line of the lunula, whereas, on the remaining toe nails, from which a lunula is almost invariably absent, it was made at a determined distance, usually five millimeters, proximal to the anterior central border of the nail bed. The amount of growth exhibited by the great toe nails was determined by measuring the distance which the mark traversed from the anterior margin of the lunula, while in the case of the other toe nails it was calculated by subtracting the distance between the mark and the anterior border of the nail bed from the distance between the latter point and the mark used as a measuring point. Thus if the mark was made at a point 5 mm. from the anterior border of the nail bed and at a later date it was 3.5 mm. from the latter point the amount of growth would be (5 mm. minus 3.5 mm.) 1.5 mm.

The daily rate of growth of the nail was ascertained by dividing the amount of growth by the number of days of growth. Thus let us suppose that in 30 days of growth the distance of the mark from the lunula on the great toe nail was 1.5 mm. The daily rate of growth in this case would be (1.5 mm. divided by 30 days) 0.05 mm. For the other toe nails the method of calculation would be the same, that is (5 mm. minus 3.5 mm.) 1.5 mm. divided by 30 days (0.05 mm.).

All measurements were made by means of a Vernier caliper calibrated in millimeters, the two measuring arms of which were sharpened in order to insure a fine degree of accuracy. All marks on the nails as well as the adjustments of the measuring arms of the Vernier to these marks were made under magnification with the use of a binocular loupé.

RESULTS

In Table I are listed the data for the 70 subjects including the daily rate of growth of each toe nail (indicated as R and L 1–5, respectively), the age, sex and mean daily rate of nail growth for each subject and for each nail. The figures indicating the rates of nail growth represent thousandths of a millimeter. Thus in subject H. A., for example, the

TABLE I

DAILY RATE OF GROWTH OF TOE NAILS

Seventy Subjects

Subject	R1	2	3	4	5	L1	2	3	4	5	Age	Sex	M
H. A.	61	37	50	50	50	61	50	48	37	50	8	M	49.4
P. B.	52	56	48	50	50	53	48	57	48	32	20	M	49.4
P. B.	72	33	66	66	50	55	66	50	83	45	22	M	58.6
H. B.	50	20	10	50	52	27	35	20	19	51	20	M	33.4
M. B.	50	50	50	50	50	66	30	50	66	45	15	F	50.7
B. B.	56	50	50	50	66	55	33	53	66	53	10	F	53.2
E. B.	50	46	25	50	75	90	75	50	48	50	35	M	55.9
H. B.	50	50	50	50	50	66	50	50	50	50	39	F	51.6
I. B.	56	56	56	56	31	56	56	56	56	31	41	F	51.0
B. B.	66	50	66	66	50	66	50	66	66	45	14	M	59.1
R. B.	66	50	50	83	83	66	50	50	50	45	44	M	59.3
T. B.	70	58	58	60	50	60	59	30	40	45	25	F	53.0
J. C.	56	50	50	50	50	85	50	50	50	50	5	M	54.1
B. C.	75	50	50	50	50	75	62	50	50	50	8	F	56.2
P. C.	75	62	50	50	50	50	62	50	50	50	3	F	54.9
M. C.	62	50	50	37	37	62	50	37	37	50	10	F	47.2
V. C.	75	75	75	50	50	55	50	50	50	50	32	F	58.0
J. C.	62	50	50	50	50	62	50	50	50	50	6	F	52.4
I. D.	50	33	40	30	50	46	50	50	50	45	15	F	44.4
M. D.	66	40	50	33	50	50	50	50	50	50	26	M	48.9
L. E.	50	50	50	50	50	50	50	50	50	45	34	M	49.5
A. E.	57	57	57	57	57	57	57	57	57	57	58	M	57.0
F. E.	57	57	57	50	50	57	57	57	48	45	28	F	53.5
E. E.	50	50	50	50	50	66	50	50	50	66	28	F	53.2
A. E.	56	50	57	50	50	57	57	57	48	45	55	F	52.7
M. E.	56	50	25	25	50	75	75	25	48	45	62	F	47.4
B. E.	60	60	60	60	60	70	50	30	70	45	19	F	56.5
L. G.	66	59	48	58	39	64	63	48	32	42	20	M	51.9
J. G.	70	50	50	50	50	55	50	50	50	50	6	F	52.5
C. G.	62	50	50	50	50	62	50	50	50	50	8	F	52.4
A. H.	50	50	48	83	50	30	66	56	66	50	26	M	54.9
M. H.	50	50	50	50	50	50	50	50	50	50	30	F	50.0
L. H.	66	40	53	36	43	66	50	50	53	40	6	F	49.7
J. H.	37	25	25	25	50	37	37	37	50	45	65	F	36.8
R. J.	50	66	66	66	83	50	66	66	83	66	23	M	66.2
G. K.	66	45	45	66	66	45	66	66	45	30	25	F	54.0
W. K.	58	27	33	40	26	49	39	36	43	45	21	M	39.6
H. K.	50	33	29	38	50	48	48	38	46	36	19	F	41.6
G. K.	58	49	69	42	40	52	42	58	50	45	20	M	50.5
M. K.	40	57	40	38	50	55	57	57	56	45	19	F	49.5
H. L.	59	54	38	14	40	51	40	35	48	45	20	M	42.4
M. L.	60	53	53	73	83	58	53	62	62	73	20	M	63.0
B. L.	44	32	44	56	47	36	42	47	53	42	18	F	44.3
S. M.	35	50	50	50	35	35	50	50	50	25	20	F	43.0
B. M.	50	51	50	50	25	50	50	50	51	25	21	F	45.2
E. M.	86	40	65	65	65	65	50	50	50	25	19	F	56.1
E. M.	60	30	30	30	30	75	30	60	30	30	21	M	40.5

TABLE I—[*Continued*]

Subject	R1	2	3	4	5	L1	2	3	4	5	Age	sex	M
L. M.....	46	28	40	50	50	36	41	54	33	45	19	F	42.3
H. M.....	48	26	35	50	50	47	58	58	58	29	30	M	45.9
P. M.....	75	50	50	50	37	75	62	37	50	37	19	F	52.3
H. P.....	43	33	40	59	33	50	50	50	50	40	16	F	44.8
R. P.....	66	66	66	66	50	73	66	50	66	66	14	F	63.5
B. P.....	33	50	33	33	50	50	33	50	33	33	10	F	39.8
D. R.....	34	34	44	48	44	48	50	50	50	48	16	F	45.0
S. R.....	75	55	55	65	25	50	65	60	65	25	19	M	54.0
J. R.....	77	44	46	81	50	74	38	55	48	45	22	M	55.8
H. S.....	40	40	40	40	40	40	40	40	40	40	60	F	40.0
A. S.....	56	45	45	45	45	45	30	45	30	45	59	M	43.1
H. S.....	90	46	30	53	50	55	18	23	30	45	34	M	44.0
W. S.....	66	50	66	33	50	40	33	33	50	66	30	F	48.7
M. S.....	47	37	53	54	50	50	24	45	54	60	21	F	47.4
H. S.....	50	50	53	50	83	50	50	50	40	50	8	M	52.6
J. S.....	40	32	52	50	50	47	38	38	57	35	22	M	43.9
R. S.....	47	53	67	70	50	46	36	60	49	40	22	M	51.8
M. W.....	52	38	38	45	38	56	38	47	45	52	28	M	44.9
D. W.....	40	66	66	66	66	66	33	40	46	50	4	M	53.9
D. W.....	50	50	50	50	50	66	66	66	66	66	7	M	58.0
D. W.....	65	45	40	60	60	75	25	48	20	45	24	M	48.3
R. Y.....	50	50	50	50	50	50	50	50	50	50	3	M	50.0
P. Y.....	50	33	60	33	50	33	33	50	50	33	6	M	42.5
Means...	56.6	46.7	48.6	50.7	50.0	55.6	48.5	48.6	49.7	45.5			50.1

daily rate of growth of the great toe nails (R and L 1) is 61 thousandths of a millimeter each, which should be translated to read 0.061 mm. and the mean rate of growth of all his toe nails (49.4 thousandths of a millimeter) as 0.0494 mm.

The mean daily rate of growth of each nail is shown in the last horizontal line of figures at the bottom of the table, each figure representing the mean daily rate of growth of 70 toe nails. The last figure (50.1) on this horizontal line is the mean daily rate of growth of all the toe nails of the whole group, that is, of 700 toe nails (70 subjects $\times$ 10 toe nails). The mean daily rate of growth per toe nail then can be stated as .050 mm. with its standard error $\pm$ .0046.

Since the rate of growth of toe nails in relation to that of finger nails in healthy individuals is a pertinent question, the average rate of toe nail growth can be said in general to be approximately half that of the finger nails, that is .050 mm. for toe nails as to .100 mm. for finger nails.

However, the whole set of observations on the rate of growth of toe nails can not be considered as strictly homogeneous, since there is considerable variation from toe to toe and from individual to individual. If these variations are subjected to analysis of variance (Snedecor, '34) several interesting features regarding their source are brought out. From the figures given in Table II the homogeneity of the several toe

means is examined by the ratio of the greater mean square to the lesser mean square. Designating this ratio by F,

$$F = \frac{\text{large mean square (869.95)}}{\text{smaller mean square (106.87)}} = 8.14$$

When this F ratio is referred to the table for an expression of the probability (Snedecor, pp. 88–91) it is found that the F of 8.14 lies beyond the 1% range expressed by an F of 2.55. That is, any variation as great as that observed would be expected to occur less than once per hundred samples if random variation alone were the sole source of differences.

TABLE II

Analysis of Variance Between Toes and Individuals

Source of Variation	Degrees Freedom	Sum of Squares	Mean Square	Standard Deviation
Total	699	103,171.80		
Between Means of Toes	9	7,829.56	869.95	
Between Means of Individuals	69	28,977.50	419.96	
Remainder	621	66,364.74	106.87	10.3380

In order to determine which toe nails differ significantly in their rate of daily growth the standard error of difference between toe means was calculated as follows:

$$\sqrt{\frac{(106.87)\ (2)}{70}} = \sqrt{3.0534} = 1.7474 \text{ thousandths of 1 mm.}$$

Corresponding to the 5% point for 500 degrees of freedom, the value of t = 1.965 (table XXXV, Snedecor). Therefore, the least mean difference that can be considered significant is (1.965) (1.7474) = 3.434 thousandths of 1 mm.

Any difference between any two toe means, listed in Table III, that is greater than 3.434 thousandths of 1 mm. can be taken as indicative of a real difference. Reading the table for complete comparisons it is evident that the rate of growth of the great toe nails is distinct from the rates of the others. In general, the nails of the 2nd, 3rd, 4th and 5th toes tend toward homogeneity in growth rate. However, some tendency toward irregularity is introduced into this grouping by the somewhat retarded growth of the left 5th toe.

In order to determine whether or not the variation in the mean rate of toe nail growth between individuals is contributing significantly to the heterogeneity of the sample, the F ratio is applied to the figures in Table II. The ratio is the larger mean square, that between means of individuals, to the remainder, or uncontrolled variation, namely, 419.96 to 106.87. Thus:

$$F = \frac{419.96}{106.87} = 3.93$$

When this ratio is compared with the values 1.54 and 1.83 for the 5% and 1% limits of significance (Snedecor, table XXXV) the value of F therefore indicates lack of homogeneity. That is, the mean daily rates

TABLE III

Differences Between Various Toe Means

	R1	R2	R3	R4	R5	L1	L2	L3	L4	L5
R1										
R2	9.87									
R3	7.97	1.90								
R4	5.84	4.03	2.13							
R5	6.56	3.31	1.41	0.71						
L1	1.00	8.87	6.97	4.84	5.56					
L2	8.07	1.80	0.10	2.23	1.51	7.07				
L3	7.93	1.94	0.04	2.09	1.37	6.93	1.40			
L4	6.83	3.04	1.14	0.99	0.27	5.83	1.24	1.10		
L5	11.06	1.19	3.09	5.21	4.50	10.06	2.99	3.13	4.23	

TABLE IV

Toe Means Based on Age Classification

		1	2	3	4	5	Mean	Standard Error
70	R	56.6	46.7	48.6	50.7	50.0		
	L	55.6	48.5	48.6	49.7	45.5		
	M	56.1	47.6	48.6	50.2	48.7	50.1	±.46
Male (33)	R	57.5	45.6	48.3	54.3	55.4		
	L	54.1	48.5	48.8	49.8	46.5		
	M	55.8	47.0	48.5	52.0	50.9	50.9	±.70
Female (37)	R	55.7	47.6	48.9	47.7	47.4		
	L	55.2	49.7	47.2	50.1	44.6		
	M	55.4	48.1	48.0	48.9	46.0	49.4	±.57
Children 1–15 yrs. (20)	R	57.6	49.3	51.8	48.3	52.6		
	L	60.4	48.4	50.5	51.3	49.4		
	M	59.0	48.8	51.0	49.8	51.0	51.9	±.73
Youths 16–25 yrs. (30)	R	56.7	44.1	47.9	53.3	47.1		
	L	53.2	47.7	48.5	49.5	39.0		
	M	54.9	45.9	48.2	51.4	43.0	48.7	±.41
Adults 26+ yrs. (20)	R	55.5	48.2	46.3	49.5	51.3		
	L	54.6	49.8	47.0	48.7	48.6		
	M	55.0	49.0	46.6	49.1	49.9	49.9	±.85

of toe nail growth from individual to individual varies significantly and is not wholly attributable to errors in random sampling. Calculating the standard error of the difference between any pair of means

of individuals by the same method as used for that between toes, any mean difference as great as or greater than 9.08 thousandths of 1 mm. can be considered as having contributing causes aside from the variation expected in random sampling.

In Table IV are tabulated the relative mean differences with their standard error of the age and sex subgroups as compared with the total group. The lack of homogeneity of nail growth between individuals is not attributable to age differences for there is almost complete lack of correlation between age and mean growth rate. The observed correlation is —0.12, and a correlation of that size might occur in at least 30% of the samples drawn from an uncorrelated population. Moreover there are no sex differences relative to toe nail growth as far as this sample is concerned, since the mean difference between daily rates of males and females is 1.4 ± .8992 thousandths of 1 mm.

TABLE V

PROBABILITIES OF MEAN DIFFERENCES BETWEEN AGE CLASSES

	Y_1	Y_{2-5}	A_1	A_{2-5}
C_1	.09	.....	.14	.....
C_{2-5}	.....	.01	.....	.54
Y_1	.....	.....	.96	.....
Y_{2-5}	.....	.....	.....	.45

However with reclassification into age groups (children 1–15; youths 16–25; adults 26+) and toe groupings, which combine the great toes in one class and the remaining toes in another, certain differences are brought out. When the mean differences are compared in terms of their standard errors and then expressed in terms of their relative probabilities, a summary tabulation, Table V, brings out the following points: the differences between the mean growth rate of the great toe nails do not depart radically from homogeneity in the age classification. The only point of real difference is between the rate of nail growth of the small toes of children and youths, here expressed by the value of .01, meaning that a mean difference as large as that observed (2.91) could occur only once per hundred times if random sampling alone contributed to the variation.

Since the great toes throughout all classifications give a more uniform measure of nail growth than the remaining toes considered as a group, it seems justifiable to use their mean rate as a standard against which to judge abnormal rates of growth. The mean rate of growth of the great toe nails here is 56.1 thousandths of 1 mm. with a standard deviation 12.3. Then, any individual whose daily rate of growth in the great toe nails exceeds 80.7 thousandths of 1 mm. (56.1. + 2 σ) or was less than 31.5 thousandths of 1 mm. (56.1 — 2 σ) could be considered as outside the range of normal growth.

The authors wish to acknowledge valuable assistance rendered by Mrs. Wilma B. Setterfield during the progress of this study.

SUMMARY

1. The mean daily rate of toe nail growth of the 70 apparently normal individuals used in this study was observed to be 50.1 thousandths of 1 mm.

2. The mean daily rate of toe nail growth on corresponding toes does not differ significantly.

3. The mean daily rate of growth of the nails of the great toes, however, is distinctly greater than the rate of the other toes, and for purposes of comparison it is suggested that this difference is worthy of account.

4. Age and mean individual rates showed no significant correlation in the observed sample.

5. There are no sex differences relative to rate of toe nail growth.

6. Age and subclassification into great and remaining toes showed that the most extreme difference in rate of toe nail growth was between the small toes of children (1–15 yrs.) and of youths (16–25 yrs.).

BIBLIOGRAPHY

Berthold, A. A. 1850. Beobachtungen über das quantitative Verhältniss der Nagel- und Haarbildung beim Menschen, Verhandl. d. Göttingen gelehrten Gesellsch.

Dufour, M. L. 1872. Observations sur la Vitesse d'accroissement des Ongles, Bulletin de la Societe Vandoise des Sciences Naturelles, 11: 195.

Heller, J. 1900. Die Krankheiten der Nägel, Berlin.

Sharpey-Schäfer, E. 1930. Observations on the relative rate of growth of the nails of the right and left hands respectively: On seasonal variations in the rate, and on the influence of nerve-section upon it. Proc. of the Royal Soc. of Edinburgh, 51: 8.

Snedecor, G. W. 1934. Calculation and interpretation of analysis of variance and covariance. Ames, Iowa.

Voit, E. 1930. Uber die Grösse der Erneverung der Horngebilde beim Menschen, Zeitschrift für Biologie, 90: 509.

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Preparation of Scientific and Technical Papers, by S. T. Trelease and E. S. Yule. 125 pp. Baltimore, The Williams and Wilkins Co., 1936. $1.50.

STUDIES ON FRESH-WATER BRYOZOA

V. Some Additions to Canadian Fauna[1]

MARY D. ROGICK
College of New Rochelle, New Rochelle, N. Y.

INTRODUCTION

The present paper adds a few species and varieties to the list of fresh-water Bryozoa which have been found previously in Canadian territory. Records by other workers exist for the Georgian Bay region, other parts of Ontario, Quebec and possibly a few other localities. Davenport (1904) gives a few records for the Canadian part of Lake Erie. White (1915) gives a brief resumé of previous finds and also adds considerably to the list. Huntsman (1913) and Geiser (1934) also cite a few localities. White mentions the following species as occurring in Canadian waters:

Paludicella articulata
Fredericella sultana
Plumatella emarginata
Plumatella repens
Plumatella fungosa
Plumatella appressa
Plumatella punctata
Pectinatella magnifica
Cristatella mucedo

Collections for the present study were made from the following Canadian islands in Lake Erie: Middle Sister, East Sister, Pelee, North Harbor, Middle and Hen and Chickens. The following species and forms were found on and around these islands:

Plumatella repens phase *alpha*
Plumatella repens phase *beta*
Plumatella repens var. *appressa*
Plumatella repens var. *emarginata*
Plumatella repens var. *furcifer*
Plumatella repens var. *jugalis*
Fredericella sultana
Paludicella articulata
Cristatella mucedo var. *idae*

[1]The opportunity for collecting was afforded by the Franz Theodore Stone Biological Laboratory of the Ohio State University, at Put-in-Bay, Ohio.

DISCUSSION OF FORMS

Plumatella repens phase **alpha** Allman 1843

The zooecia are adherent in their entire length. They are reddish-amber in color, translucent to transparent and branch very openly instead of becoming compact. A fuller discussion of this form is found in Study II of this series. It was collected between July 5 and August 28, 1933, from Big Chicken, Middle Sister and Middle Islands, from protected localities along the shore. New to Canada.

Plumatella repens phase **beta** Allman 1848

This form resembles phase *alpha* markedly in coloration, size, zooecial characters and general mode of branching. It differs in that the tubes are not entirely adherent, but that most of the tubes are bent upward at the distal portion of the zooecium. Some of the tubes are upright in a large part of their extent. The tentacles number about 50 to 55. Gradations between phases *alpha* and *beta* are not uncommon. Some colonies are so intermediate that it is impossible to allocate them to either form with absolute certainty.

Collections were made between June 27 and August 28 at the following islands: Pelee, East Sister, Middle Sister and Big Chick. This phase appeared in boulder-protected localities on the under side of stones. New to Canada.

Plumatella repens var. **appressa** (Kraepelin) 1887

1887. *Plumatella polymorpha* var. b, *appressa*. Kraepelin.
1904. *Plumatella polymorpha* var. b, *oppressa*. Davenport.
1915. *Plumatella appressa*. White.
1926. *Plumatella repens* (var. *appressa*)? Despax.
1927. *Plumatella fungosa* var. *appressa*. Abricossoff.

In this form vertical tubes are lacking or very rare. Zooecia are repent, thickly intertwined or pressed closely together on the substratum. The branching is angular. This feature is particularly apparent when a colony is viewed from the attached side. Kraepelin and White mention a clear longitudinal band or low keel as being frequently present. Those features did not appear in the Lake Erie specimens.

The colonies were collected between July 17 and August 28 from North Harbor, Hen and Chickens Islands. They were found on the under side of large stones in localities protected by rocks and boulders. White found it abundant in the Georgian Bay region.

Plumatella repens var. **emarginata** (Allman) 1844

1844. *Plumatella emarginata*. Allman.
1885. *Plumatella repens* (partim). Jullien.
1887. *Plumatella princeps* var. *emarginata* (partim). Kraepelin.
1894. *Plumatella repens* var. *emarginata*. Vangel.
1915. *Plumatella emarginata*. White.

The most conspicuous feature of this variety is the emarginate orifice which connects with the keeled furrow. The tubes are long, cylindrical and keeled. They range in color from a very dark brown to a sandy

color, with lighter tips. Tentacles number from 40 to 54. The polypidom is adherent in the greater part of its length. Its branching is open, antler-like and dichotomous.

Statoblasts, in spite of their great variability, have been used as criteria for the identification of species to such an extent that they can not be disregarded. The majority of the free statoblasts of *emarginata* are elongate, less than twice as long as broad but more than 1½ times as long. The annulus covers almost the whole of the upper surface, leaving a small exposed central capsule area.

The distribution of this form is very wide, in North America, Europe, Asia and Africa. Davenport (1904), Osler ? (1883), Huntsman (1913) and White (1915) reported it from various localities in Canada. In the 1932–33 collections it was found on or around East Sister, Middle Sister, Middle, Pelee, Hen and Chickens Islands. The best specimens came from protected localities or pond habitats.

Plumatella repens var. **furcifer** Jullien 1885

Only a few colonies of this form were found—at Pelee Island, on August 22. The habitat was a protected shore locality where coarse rubble, mud and sand were present. This form is more luxuriant ordinarily in pond habitats.

Variety *furcifer* is easily recognized wherever encountered by the transparent, bifurcated, longitudinal area which is present on most of the zooecia, although it sometimes is not very conspicuous. The ectocyst varies from a reddish-brown color to transparency, and, is not very rigid. The orifice is emarginate. Tentacles number about 50. The tubes are entirely adherent. The branching is open. New to North America.

Plumatella repens var. **jugalis** (Allman) 1850

The zooecia are entirely adherent and provided with a keel. The colony is geminate and the branching is very open. Tentacles number about 40. No other variety except *flabellum* possesses the geminate character whereby two portions of the colony are connected basally, by a tube. *Flabellum* can be easily distinguished from *jugalis* in its extremely luxuriant branching and flabellate character. The variety *jugalis* was found in only one Canadian locality—in an old canal on Pelee Island on June 21. New to North America.

Fredericella sultana (Blumenbach) 1777

1777. *Tubularia sultana.* Blumenbach.
1836. *Plumatella sultana.* Dumortier.
1887. *Fredericella sultana.* Kraepelin.

This species resembles the Plumatellas very closely. It branches antler-like, with long cylindrical tubes either recumbent, erect or a combination of both. The branching is very open, even in "bushy" colonies. No free statoblasts are found. The attached stoblasts show various markings. In young statoblasts the unattached surface is more or less smooth while in old statoblasts the surface is roughened. The shape of these reproductive bodies is variable—some of them may be reniform, some oval, others almost quadrangular and still others almost

circular. The average length of the Erie specimens was 0.366 mm. and the average breadth was 0.199 mm.

Abricossoff recognized several varieties of *F. sultana*. However, these varieties should be more carefully and fully described and illustrated.

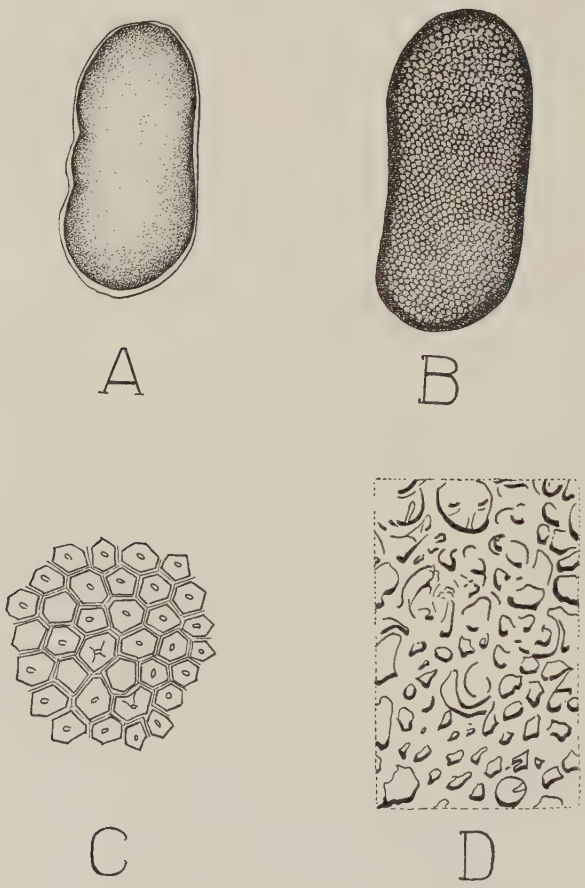

FIG. 1. *A*.—A young statoblast of *Fredericella sultana*. The unattached surface is quite smooth. Dimensions 0.4176 mm. long, 0.1914 mm. wide. *B*.—An older statoblast of *F. sultana*. *C*.—An enlarged drawing of the surface of *B*. *D*.—A portion of the roughened surface of an old statoblast of *F. sultana*. The magnification is the same as in *C*. All figures were made with the aid of a camera lucida.

Fredericella sultana has been recorded from a number of localities in North America, Europe, Asia, Australia and South America. White found it in the Georgian Bay region while Huntsman recorded it from Bond Lake in the Toronto district. In Lake Erie it was present in collections from Pelee, North Harbor, Middle, Middle Sister, East Sister, Hen and Chickens.

Paludicella articulata (Ehrenberg) 1831

1831. *Alcyonella articulata.* Ehrenberg.
1836. *Paludicella articulata.* Gervais.
1856. *Paludicella Ehrenbergi.* Allman.
1887. *Paludicella Ehrenbergii.* Kraepelin.

This species is very readily recognized when seen in the collections. Its zooceia are club-shaped, elongate and very slender. They are almost 2 mm. long. The circular lophophore bears 16 to 18 tentacles. The lateral buds may be repent or erect. The tubular orifice is squared at the tip and is placed distally with respect to the enlarged portion of the body. The Erie individuals varied considerably both in length and width of zooecia. This species is very common in the southwestern part of the Lake. It is rather surprising that neither Davenport nor Landacre listed its occurrence in the Lake—unless of course it may have been introduced there later. It occurred at Hen, Middle, Southeast Chicken, Northwest Chicken, Big Chicken, East Sister, Middle Sister, North Harbor and Pelee Islands. Collections of this form were made between June 21 and August 30.

Cristatella mucedo var. **idae** (Leidy) 1858

1858. *Cristatella Idae.* Leidy.
1887. *Cristatella mucedo* var. *Idae.* Kraepelin.
1908. *Cristatella mucedo.* Loppens.

The Lake Erie variety agreed in a number of features with Kraepelin's *Idae.* The colonies were ribbon-like and had three marginal rows of polypides. Tentacula numbered between 70 and 74. Very few statoblasts were found, but, those which were available, had approximately 24 hooks on one side and 45 on the other. The diameter of one statoblast was 1.075 mm.

The question as to the validity of the varieties *idae* and *genuina* was referred to in Study II and will not be discussed here. Variety *idae* has not been recorded from Lake Erie by either Davenport or Landacre. The writer has found it in only three Canadian localities: Big Chick, East Sister and Middle Sister Islands. Davenport records Reighard's findings of the variety *genuina* at Long Point, Canada. New to Canada.

SUMMARY

1. At least nine species and varieties of fresh-water Bryozoa have been recorded from Canada by earlier workers.
2. The present study discusses nine species, varieties and phases, which were collected on and around several islands in the southwestern part of Lake Erie (Canadian territory), during the summers of 1932 and 1933.
3. Of these nine forms of the present study two were new for North America:
   (a) *Plumatella repens* var. *jugalis*
   (b) *Plumatella repens* var. *furcifer*

4. Three forms, subdivisions of previously recorded species, have also been added to the list:
   (a) *Plumatella repens* phase *alpha*
   (b) *Plumatella repens* phase *beta*
   (c) *Cristatella mucedo* var. *idae*

BIBLIOGRAPHY

Abricossoff, G. G. 1927. Über die Süsswasser-Bryozoen der USSR. Compt. Rend. de l'Acad. Sci. USSR, 1927, pp. 307–312.
Allman, G. J. 1856. Monograph of fresh-water Polyzoa. Ray Soc., London, 119 pp.
Davenport, C. B. 1904. Report on the Fresh-Water Bryozoa of the United States. Proc. U. S. Nat. Museum, XXVII: 211–221.
Despax, R. 1926. Bryozoaires Rencontres dans Quelques Lacs Pyreneens. Bull. Soc. Hist. Nat. Toulouse, LIV: 18–23.
Geiser, S. W. 1934. The Distribution of Pectinatella magnifica in the United States. Field and Laboratory, II: 56–59.
Huntsman, A. G. 1913. Invertebrates Other Than Insects and Mollusks. Chap. XX of The Nat. Hist. of the Toronto Region edited by J. H. Faull, Canadian Institute, pp. 277–278.
Jullien, J. 1885. Monographie des Bryozoaires d'Eau Douce. Bull. Soc. Zool. de France, X, 119 pp.
Kraepelin, K. 1887. Die deutschen Süsswasserbryozoen. Abh. aus dem Naturw. Naturw. Ver. Hamburg, X, 168 pp.
Landacre, F. A. 1901. Sponges and Bryozoans of Sandusky Bay. Ohio Naturalist, I: 96–97.
Loppens, K. M. 1908. Les Bryozoaires d'Eau Douce. Ann. biol. lacustre, III: 141–183.
Rogick, M. D. 1934. Additions to North American Fresh-Water Bryozoa. Ohio Jour. Sci., XXXIV: 316–317.
1935. Studies on Fresh-Water Bryozoa, II. Trans. Amer. Micr. Soc., LIV: 245–263.
Vangel, E. 1894. Daten zur Bryozoen-Fauna Ungarns. Zool. Anz., XVII: 153.
White, H. T. 1915. Bryozoa of the Georgian Bay Region. Suppl. 47th Report, Dept. Fisheries, Ottawa, Fasc. II: 195–199.

Plant Hormones

The first comprehensive account of plant growth substances will be welcomed by botanists and biologists generally. It is a volume which plugs an obvious gap on every botanical bookshelf. The book is basically a translation and revision of Boysen-Jensen's "Die Wuchsstofftheorie." The author's original version has been considerably rearranged and brought up to date with the inclusion of the literature through 1935. The reorganization and revision have been skillfully done. The result is a straightforward, lucid account of present knowledge of the roles of growth substances in plants. The text is adequately supported with illustrations. About 500 papers are listed in the bibliography. A supplementary bibliography lists about 150 titles on the subject of the effects of "bios" and other similar substances on plant growth. These are not, however, discussed in the text.—B. S. Meyer.

Growth Hormones in Plants, by G. S. Avery and P. R. Burkholder. 268 pp. New York, the McGraw-Hill Book Co., 1936. $3.50.

SOME NEW SPECIES OF BALLANA (HOMOPTERA CICADELLIDAE)

DWIGHT M. DeLONG
Ohio State University

During the past six years the writer has been studying the species of this genus, determining and illustrating both male and female genital characters. It was planned to publish the illustrations with the descriptions of all the species in the genus. Certain conditions, however, have indicated the advisability of publishing the following descriptions in order to use the names for the identification of species. As a consequence the portions of the descriptions concerned with the dorsal pieces of the male genitalia, which offer excellent characters for separation, are omitted as are the several plates of illustrations. These will appear at a later date after the names are established. The material upon which this study has been based is contained in the collections of Dr. E. D. Ball and the author. Dr. Ball has furnished type material of previously described species and unidentified material, a considerable amount of which has proved to be undescribed. The author is greatly indebted for this assistance and desires to express his grateful appreciation to Dr. Ball.

Ballana atridorsum (Van Duzee)

Thamnotettix atridorsum V. D. Can. Ent. 36:92, 1894.

The original female type of this species was destroyed and Professor Herbert Osborn erected a topotype ♂ from the same series. This is in the Iowa State College Collection labeled Colo. 581. It is here designated as the neotype and the genitalia are thus described:

Male plates slightly longer than combined basal width, sides almost straight, apices rather broad, rounded, extending to the posterior spines. Male in dorsal view with ninth segment broader than long, narrowed from base to apex. Anterior spines very short, arising at posterior portion and directed caudally. Posterior spines long and heavy, extending beyond median line and slightly curving upward.

Ballana delea n. sp.

Resembling *atridorsum* but with distinct genitalia. Length 5 mm.

Vertex produced, bluntly angled, and bluntly angled with front, about one third wider between eyes than length at middle.

Genitalia: Female last ventral segment with lateral angles rounded, posterior margin between these slightly indented, forming a broad

median truncated portion. Male plates broad, only slightly longer than combined basal width, strongly convexly rounded to bluntly pointed apices which do not reach to the posterior spines.

Described from a pair of specimens from Santa Barbara, California, collected in June, 1918. Holotype male and allotype female in author's collection.

Ballana calcea n. sp.

Resembling *atridorsum* in general appearance but smaller and with distinct genitalia. Length 5 mm.

Vertex bluntly angled, length at middle more than half basal width between eyes, margin of vertex thick.

Color: Pale green, vertex yellowish green.

Genitalia: Female last ventral segment with lateral margins convexly rounding to form broadly rounded lobes between which the central third of the posterior margin is slightly excavated. The posterior margin of the excavation slightly convexly rounded. Male plates long, slightly longer than combined basal width, sides almost straight, apices blunt, rounded, reaching almost to posterior spines.

Described from a series of six male and two female specimens collected at Bunkersville, Nevada, April 17, 1929, (Davis); two males and two females, Glendale, Nevada, May 5, 1929, (Fox) from *Hymenoclea salsola;* and one female as Mesquite, Nevada, June 7, 1929, from *Franseria eriocentra.* Holotype male, allotype female (Bunkerville, Nevada) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana brevidens n. sp.

Resembling *atridorsum* in general form and appearance but with distinct genitalia. Length 5.5 mm.

Vertex slightly produced, bluntly angled, bluntly angled with front, twice as wide between eyes as length at middle.

Color: Yellowish, elytra very pale, dull green, apices of elytra slightly smoky.

Genitalia: Female last ventral segment with lateral angles broadly rounded to median third of posterior margin which is indented, almost truncate and black margined. Male plates about as long as combined width at base, sides almost straight, apices bluntly pointed, just reaching the posterior spines.

Described from one male and six female specimens collected at Minidoka, Idaho, June 24, 1930. Holotype male, allotype female and female paratypes in the author's collection. Female paratype in Ball Collection.

Ballana transea n. sp.

Resembling *atridorsum* in general appearance but with vertex more produced and with distinct genitalia. Length 5 mm.

Vertex produced and bluntly angled, margin thick, bluntly angled with front about one third wider between eyes than length at middle.

Color: Vertex pronotum and scutellum yellowish, elytra dull green.

Genitalia: Female last ventral segment short, posterior margin practically truncate, scarcely indented, central two thirds broadly dark margined. Male plates about as long as combined basal width, sides almost straight, apices bluntly pointed, reaching to posterior spines.

Described from three specimens from Colorado without specific data. Holotype male, allotype female and female paratype in author's collection.

Ballana adversa n. sp.

Resembling *atridorsum* in general form and appearance but smaller and with distinct genitalia. Length 4.5 mm.

Vertex produced and bluntly angled, two thirds as long at middle as basal width between eyes, margin thick and bluntly angled with front.

Color: Yellowish, pronotum and elytra tinged with green, apices of elytra slightly smoky.

Male plates a little longer than combined basal width, sides straight, apices blunt, rounded, reaching the posterior spines.

Described from two male specimens collected at Stansburg I. Park, Utah, June 13, 1913, by Hagan Titus; two males from Santa Clara, Utah, May 5, 1929, (Fox). Holotype male and male paratypes in author's collection. Paratype male in Ball collection.

Ballana firma n. sp.

In form and general appearance resembling *atridorsum* but with distinct genitalia. Length 5 mm.

Vertex produced but bluntly angled and bluntly angled with front. One fifth wider between eyes than length at middle.

Color: Vertex, anterior margin of pronotum and scutellum yellow, disc of vertex and elytra dark green, veins paler. Apices of elytra black to anterior cross veins of inner and outer apical cells.

Genitalia: Female last ventral segment convexly rounded from near base to posterior margin which is deeply concavely rounded between these two pointed lobe-like portions. Male plates a little longer than combined basal width, side margins convexly rounded to blunt rounded apices which reach beyond the posterior spines.

Described from a series of two male and one female specimens collected at Alpine, California, July 5, 1931, by Dr. E. D. Ball. Holotype male and allotype female in Ball collection. Paratype male in author's collection.

Ballana prava n. sp.

In form and general appearance resembling *firma* but more slender, with vertex more produced and with distinct genitalia. Length 5 mm.

Vertex produced and bluntly angled, almost one-half wider between eyes than length at middle.

Color: Vertex yellow, pronotum, scutellum and elytra green. Apices of elytra black as far forward as cross veins of apical cells.

Genitalia: Male plates not quite as long as combined basal width, triangular, sides almost straight, slightly concave, apices bluntly pointed, not reaching posterior spines by about one-third their length.

Described from two male specimens collected at San Luis Obispo, California, collected June 14, 1934, by Dr. E. D. Ball. Holotype male and paratype male in Ball collection.

Ballana elexa n. sp.

Resembling *firma* in general appearance and coloration but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, margin of vertex thick, one-third wider between eyes than length at middle.

Color: Vertex, anterior margin of pronotum and scutellum yellowish, disc of pronotum and elytra yellowish green, veins paler, apices of elytra dusky to brown.

Genitalia: Female last ventral segment convexly rounded from near base to form posterior margin which is almost truncate, slightly indented either side of median third. Male plates about as long as combined basal width side margins almost straight, apices broad, bluntly pointed on inner margin, not reaching to posterior spines.

Described from a series of two male and two female specimens collected at Pine Valley, California, July 6, 1931, by Dr. E. D. Ball. Holotype male and allotype female in Ball collection. Male and female paratypes in author's collection.

Ballana attenuata n. sp.

Resembling *vivata* in general appearance but with distinct genitalia. Length 5 mm.

Vertex strongly produced and bluntly angled, bluntly angled with front, one-fourth wider between eyes than length at middle.

Color: Vertex and scutellum yellow, pronotum and elytra green washed with yellow, veins indistinct except at apex where they are pale on a slightly smoky, subhyaline apical portion.

Genitalia: Male plates as long as combined basal width, more than half as broad at apex as width at base, apices broadly rounded, reaching posterior spines.

Described from a single male specimen collected at Pine Valley, California, July 6, 1931, by Dr. E. D. Ball. Holotype male in Ball collection.

Ballana filamenta n. sp.

Resembling *attenuata* in form and general appearance but with blunter head and distinct genitalia. Length 6–6.5 mm.

Vertex well produced and rather sharply angled, acutely angled with front, one-half wider between eyes at base than median length.

Color: Vertex and anterior portion of pronotum yellow, disc of pronotum, scutellum and elytra green. Veins of elytra pale, apices subhyaline.

Genitalia: Female last ventral segment with lateral margins slightly narrowed and produced, posterior margin forming two broadly rounding lobes between which is a broad U-shaped notch extending two thirds the distance to base and broadly black margined at apex. Male plates a little longer than combined basal width, at least one-third as wide at apex as base, apices broadly rounded, not reaching posterior spines.

Described from a male and female specimens from Yosemite, California, collected June 28, 1931, and a female from Santa Margarita, California, collected June 23, 1931, all by Dr. E. D. Ball. Holotype male, allotype female (both from Yosemite) in Ball collection. Female paratype in author's collection.

Ballana mera n. sp.

Resembling *filamenta* in general form and appearance but with vertex more bluntly angled and with distinct genitalia. Length 5.5 mm.

Vertex produced and bluntly angled, one and one-third times as wide between eyes at base as length at middle.

Color: Vertex, yellow; pronotum, scutellum and elytra green washed with yellow, veins paler.

Genitalia: Female last ventral segment with lateral margins convexly rounded from about half its length to posterior margin which is truncate at middle. Male plates not quite as long as combined basal width, convexly rounded to broadly rounded apices which do not reach posterior spines by more than one-third their length.

Described from a series of two male and one female specimens collected at Muir Woods, California, June 17, 1934, by Dr. E. D. Ball. Holotype male, allotype female in Ball collection. Paratype male in author's collection.

Ballana quira n. sp.

In form and general appearance resembling *atridorsum* but with distinct genitalia. Length 5–5.5 mm.

Margin of vertex thick, vertex bluntly angled, more than one-half wider between eyes than length at middle.

Color: Vertex, anterior margin of pronotum and scutellum yellowish. Disc of pronotum and elytra dull yellowish green.

Genitalia: Female last ventral segment strongly convexly rounding from about half its length to almost truncate posterior margin, the central third of which is slightly indented but truncate. Male plates about as long as combined basal width, sides almost straight, apices rather broad, rounded to bluntly pointed tips, not reaching to posterior spines.

Described from two male and two female specimens collected at Sunset Park, Arizona, June 23, 1935, by Dr. E. D. Ball. Male holotype, female allotype and male and female paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana nigridens n. sp.

Resembling *atridorsum* in general appearance but with vertex blunter and with distinct genitalia. Length 6.5 mm.

Vertex bluntly angled, margin thick, bluntly angled with front, more than twice as wide between eyes as length at middle.

Color: Vertex yellow, pronotum dull green, anterior margin yellowish. Elytra dull greenish, apices slightly smoky, arcs on face pale brown, slightly visible from above.

Genitalia: Female last ventral segment strongly produced and narrowed, posterior margin broadly slightly indented forming a slightly

rounded median lobe. Male plates rather long, almost one-fourth longer than combined width at base, slightly concavely narrowed on outer margin about middle, apices bluntly pointed, not reaching end of anal tube.

Described from a pair of specimens collected at Jemez Springs, N. M., June 15, 1919. Holotype male and allotype female in the author's collection.

Ballana spinosa n. sp.

Resembling *atridorsum* in general appearance but with more bluntly angled vertex and distinct genitalia. Length 6 mm.

Vertex very blunt, almost rounded in front, margin thick, rounding to front, almost twice as wide as length at middle.

Color: Vertex pale yellow, pronotum, scutellum and elytra dull greenish.

Genitalia: Female last ventral segment with posterior margin indented on median half forming a slightly sunken truncate lobe. Male plates short and broad, only slightly longer than combined basal width, convexly rounded to form obliquely rounding apices which do not reach the junction of the posterior spines.

Described from a series of four male and three female specimens collected at Idaho City, Idaho, July 13, 1930, by the author. Holotype male, allotype female and male and female paratypes in the author's collection.

Ballana polica n. sp.

Resembling *spinosa* in general form and appearance but with distinct genitalia. Length 5.5 mm.

Vertex blunt, scarcely produced at middle, twice as wide between eyes at base as length at middle, margin thick, almost rounded to front.

Female last ventral segment with lateral angles rounded, median third of posterior margin indented, concavely rounded. Male plates about as long as combined basal width, sides convexly rounded, apices rather broad and blunt, reaching the posterior spines.

Described from a male specimen from Aberdeen, Idaho, June 26, 1930, (DeLong); and eight females and fourteen males from Craters of the Moon, Idaho, June 29, 1930. Holotype male, allotype female and male and female paratypes in the author's collection. Male and female paratypes in Ball collection.

Ballana parallela n. sp.

Resembling *spinosa* in general appearance but with distinct male genitalia. Length 5 mm.

Vertex scarcely produced, rounded, almost half as long at middle as basal width between eyes, margin thick, bluntly angled with front.

Color: Yellowish, elytra slightly tinged with dull green.

Male plates a little longer than combined width at base, sides convexly rounded, apices blunt, rounded, not reaching the posterior spines. Male in dorsal view with ninth segment broader than long. Anterior spines and posterior spines long, straight and heavy, both pairs extending obliquely caudally so that they appear parallel.

Described from one male specimen collected at Twin Falls, Idaho, Aug. 30, 1927, which seems unique and to deserve specific treatment. Holotype male in author's collection.

Ballana curvidens n. sp.

Resembling *spinosa* in form and appearance but with distinct genitalia. Length 5.5 mm.

Vertex roundedly produced but scarcely angled, margin thick, rounding to front, almost twice as wide between eyes as length at middle.

Color: Vertex yellowish, pronotum, scutellum and elytra dull greenish.

Genitalia: Last ventral segment with posterior margin forming a slightly indented median lobe on central half. Male plates rather long, about one-fourth longer than combined basal width, slightly convexly rounded to bluntly pointed apices which do not reach the end of the anal tube.

Described from a series of 38 specimens. Four male specimens from Minidoka, Idaho, June 24, 1930; 7 males and 14 females from American Falls, Idaho, June 25, 1930; 8 males and 5 females, Twin Falls, Idaho, June 14, 1930; and one male, Craters of the Moon, Idaho, June 29, 1930, all collected by the author. Holotype male (Minidoka, Idaho) allotype female (American Falls) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana ortha n. sp.

Resembling *spinosa* in form and general appearance but with distinct genitalia. Length 5.5 mm.

Vertex produced and rounded at apex, margin very thick, rounded to front, about twice as wide between eyes as length at middle.

Color: Vertex and scutellum yellowish, pronotum and elytra dull green.

Genitalia: Last ventral segment of female with central half of posterior margin roundedly produced forming a broad, truncated lobe which is heavily black margined and more caudal than remainder of segment. Male plates not quite as long as combined basal width, triangular, gradually narrowed to bluntly pointed apices which do not reach to the branches of the posterior spines.

Described from a male specimen collected at Logan Canyon, Utah, July 24, 1930, (DeLong); four females and one male, Minidoka, Idaho, June 24, 1930, (DeLong); four males, Overton, Nevada, July 7, 1929, (Fox); one female, Cove Fort, Utah, July 6, 1928, (Davis); two females, Bliss, Idaho, June 6 and 16, 1930; and four males and four females from Dixie, Utah, June 27, 1931, (Ball). Holotype male allotype female (Minidoka, Idaho) and male and female paratypes in author's collection, male and female paratypes in Ball collection.

Ballana calcara n. sp.

Resembling *spinosa* in general form but with distinct genitalia. Length 5.5 mm.

Vertex bluntly angled, almost half as long at middle as basal width between eyes.

Color: Vertex and pronotum yellow, scutellum pale green, elytra rather bright green, margin thick.

Genitalia: Female last ventral segment with lateral margins produced almost straight from base to broadly curved outer lobes of posterior margin between which the central third is rather deeply, broadly excavated, the apical truncated margin of which is broadly embrowned. Male plates as long as combined basal width, convexly rounded to blunt apices, reaching only about two thirds the distance to the posterior spines.

Described from five male and five female specimens collected at Dunphy, Nevada, Aug. 5, 1930, from *Chrysothamnus* sp. Holotype male, allotype female and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana hebea n. sp.

Resembling *calcara* in form and size but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, more than half as long on middle as basal width between eyes, margin thick.

Color: Pale, dirty yellow, elytra slightly tinged with green. Veins pale, conspicuous.

Genitalia: Female last ventral segment with lateral margins convexly rounding to form rounded lobes of posterior margin between which the median third is distinctly abruptly excavated, the apex of which is truncated. Male plates a little longer than combined basal width, appearing long, sides almost straight, apices blunt, slightly longer than distance to posterior spines.

Described from a series of two male specimens collected at Benjamin, Utah, July 23, 1930, (DeLong); one male from Brigham, Utah, July 5, 1929, (Knowlton); five males and two females, Ely, Nevada, July 9, 1930 (Davis and Dorst); four females, N. Payson, Utah, July 25, 1930, (DeLong); two males, Richfield, Utah, July 15, 1929, (Dorst); June 21, 1930, (Davis); one male, Elko, Nevada, July 12, 1930, (Dorst).

Holotype male (Benjamin, Utah) allotype female (N. Payson) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana occidentalis n. sp.

Resembling *calcara* in form and general appearance but with vertex more blunt and with distinct genitalia. Length 5.5 mm.

Vertex bluntly angled, not more than one-half broader between eyes than length at middle.

Color: Vertex yellow, pronotum, scutellum and elytra pale, dull green, apices of elytra smoky.

Male plates together slightly broader than long, lateral margins convexly rounded, apices blunt, rounded, extending only about two-thirds the distance to posterior spines.

Described from two male specimens from Elko, Nevada, collected July 12, 1930, from *Chrysothamnus*. Holotype male and paratype male in author's collection.

Ballana absenta n. sp.

Resembling *calcara* in general form but paler in color and with distinct genitalia. Length 5.5 mm.

Vertex bluntly angled, almost twice as wide between eyes as length at middle, anterior margin thick.

Color: Pale straw yellow, elytra slightly tinted with green.

Genitalia: Female last ventral segment with lateral margins convexly rounding to form produced, angular lobes either side of a broad excavated central half with truncated margin and excavated about one-fourth the distance to the base. Male plates small, about as long as combined width at base, sides almost straight, apex blunt, rounded, not reaching posterior spines by about one-third their length.

Described from six female and one male specimens collected at Overton, Nevada, June 6 and July 7, 1929, (Fox); one female and one male, St. George, Utah, June 4, 1930, (Davis); three females, Glendale, Nevada, May 5, 1929, (Fox); one female, Richfield, Utah, August 7, 1916. Holotype male (Overton, Nevada) allotype female (same) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana coarcta n. sp.

Resembling *callida* in general appearance but with blunter vertex and distinct genitalia. Length 5 mm.

Vertex strongly produced, apex bluntly angled, one-fourth wider between eyes at base than median length.

Color: Vertex and scutellum yellowish, elytra and disc of pronotum dull greenish, apex of elytra black.

Genitalia: Female last ventral segment decidedly narrowed to posterior margin which is broadly, shallowly emarginate more than half its width. Male plates long and slender, longer than combined basal width, sides concave, apices bluntly pointed, almost reaching to posterior spines.

Described from a male and two female specimens collected at Alpine, California, July 5, 1931, by E. D. Ball. Holotype male and allotype female in Ball collection, female paratype in author's collection.

Ballana sera n. sp.

Resembling *atridorsum* in form and general appearance but larger, with vertex more bluntly angled and with distinct genitalia. Length 6–6.5 mm.

Anterior margin thick, vertex bluntly angled, one and one-half times as wide between eyes as length at middle.

Color: Vertex, anterior margin of pronotum and scutellum yellowish. Disc of pronotum and elytra yellowish, appearing green where covering abdomen.

Genitalia: Female last ventral segment with lateral margins convexly rounding from near base to posterior margin, the central third of which is abruptly excavated about one-fourth the distance to base, the base of which is slightly convexly rounded. Male plates about as long as

combined basal width, sides convexly rounded, apices bluntly pointed, not reaching to posterior spines by about one-fourth their length.

Described from a series of two female and three male specimens collected at Beaumont, California, June 12, 1931, by Dr. E. D. Ball. Male holotype, female allotype in Ball collection. Male paratype in author's collection.

Ballana plena n. sp.

Resembling *sera* in general appearance but with broader head and distinct genitalia. Length 5.5–6 mm.

Vertex very broadly, bluntly angled, margin thick, slightly more than one and one-half times as wide as median length.

Color: Vertex, anterior margin of pronotum and scutellum yellow, brownish arcs of front extending up onto anterior margin of vertex. Disc of pronotum and elytra green washed with yellow, veins of wing paler.

Genitalia: Female last ventral segment with lateral margins convexly rounding from near base to posterior margin which is broadly V-shaped, notched at center, about one-third the distance to base. Apex of notch broadly black. Male plates as long as combined basal width, sides slightly convexly rounded, apices broad, obliquely sloping to blunt apices, not reaching posterior spines.

Described from one male and one female specimens collected at Pine Valley, California, July 6, 1931, by Dr. E. D. Ball. Male holotype and female allotype in Ball collection.

Ballana gruis n. sp.

Resembling *vesca* in general form and appearance but with distinct genitalia. Length 4–5 mm.

Vertex bluntly angled, almost rounded in front, margin thick, one-fourth wider between eyes than length at middle.

Color: Vertex pronotum and scutellum yellowish, disc of pronotum green. Elytra green, veins yellowish.

Genitalia: Female last ventral segment convexly roundedly narrowed to posterior margin which occupies the middle half of segment and is truncated or slightly convexly rounded. Lateral plates prominent. Male plates about as long as combined basal width, sides almost straight, apices bluntly pointed, almost rounded, not quite reaching to posterior spines.

Described from a male and two female specimens collected at Oxnard, California, June 21, 1931, by Dr. E. D. Ball. Holotype male allotype female in Ball collection. Paratype female in author's collection.

Ballana indens n. sp.

In general appearance resembling *vetula* but with distinct genitalia. Length 5–5.5 mm.

Vertex bluntly angled, almost rounded, one-third wider between eyes at base than median length. Margin thick.

Color: Pale yellow, pronotum and elytra slightly darker.

Genitalia: Female last ventral segment narrowed to apex, lateral angles bluntly rounded between which the posterior margin is slightly emarginate and truncate. A heavy black mark causes it to appear rather deeply and doubly notched. Male plates about as long as combined basal width, broadly triangular, apices broadly blunt and rounded, not reaching posterior spines by about one-third their length.

Described from two male and two female specimens collected at Doyle, California, July 21, 1912. Holotype male, and allotype female in Ball collection. Male and female paratypes in author's collection.

Ballana diutia n. sp.

In form and appearance resembling *vesca* but with distinct genitalia. Length 4.5 mm.

Vertex bluntly angled almost twice as wide between eyes as length at middle. Margin thick, almost rounded to front.

Color: Vertex and scutellum yellow, pronotum and elytra gray tinged with yellow.

Male plates about as long as combined basal width, sides convexly rounded, apices broad, rounded, reaching almost to posterior spines.

Described from a single male specimen collected at Mojave, California, July 1, 1931, by E. D. Ball. Holotype male in Ball collection.

Ballana pleura n. sp.

Resembling *atridorsum* in general form and appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex produced and bluntly angled, one and one-half times as wide between eyes at base as median length.

Color: Male, vertex and scutellum yellow, pronotum and elytra green, veins paler, apices of elytra smoky. Female yellowish washed with brown, veins pale.

Genitalia: Female last ventral segment with lateral margins strongly, convexly rounded from base to posterior margin which is truncated on central third and slightly indented. Male plates about as long as combined basal width, concavely rounded on outer margins to form bluntly pointed apices, which do not reach to the posterior spines.

Described from a series of three male and one female specimens collected at Santa Margarita, California, June 23, 1931, by Dr. E. D. Ball. Holotype male, allotype female and male paratype in Ball collection. Paratype male in author's collection.

Ballana hama n. sp.

Resembling *pleura* in general appearance but with more produced vertex and distinct genitalia. Length 4.5 mm.

Vertex strongly produced and bluntly angled, one and one-half times as wide between eyes as length at middle.

Color: Greenish washed with yellow, pale brownish arcs extending onto margin of vertex from front. A pair of small brown spots on base of vertex. Elytra with apices smoky, veins pale.

Genitalia: Female last ventral segment with lateral margins obliquely sloping to posterior margin which is slightly excavated on

median third and truncated. Male plates as long as combined width at base, sides almost straight, apices bluntly pointed, almost reaching posterior spines.

Described from a series of two male and one female specimens collected at Beaumont, California, June 12, 1921, by Dr. E. D. Ball. Holotype male and allotype female in Ball collection. Paratype male in author's collection.

Ballana valga n. sp.

Resembling *pleura* in form but with pale yellow color and distinct genitalia. Length 5 mm.

Vertex bluntly angled only slightly produced, one and two-thirds times as wide between eyes as median length, margin thick.

Color: Pale yellowish without definite markings, veins pale.

Genitalia: Female last ventral segment with lateral margins strongly convexly rounding from base to posterior margin which is shallowly, evenly and rather broadly concave. Male plates as long as combined basal width, side margins slightly concavely rounded to form bluntly pointed apices which do not reach the posterior spines by about one-fourth their length.

Described from a series of one male and two female specimens collected at Provo, Utah, August 9, 1930. Holotype male and allotype female in Ball collection. Paratype female in author's collection.

Ballana angula n. sp.

In general form resembling *valga* but with greenish color and distinct genitalia. Length 5 mm.

Vertex only slightly produced and bluntly angled, twice as wide between eyes at base as median length.

Color: Male pale green tinged with yellow, female pale yellow, unmarked.

Genitalia: Female last ventral segment with lateral margins strongly convexly rounded from base to posterior margin which is slightly and broadly excavated, the posterior margin of which is convexly rounded. Male plates about as long as combined basal width, side margins straight, apices rather broad, rounded, not reaching posterior spines by about one-third their length.

Described from four male and two female specimens collected at Gila Bend, Arizona, April 13, 1933, by Dr. E. D. Ball. Holotype male, allotype female and paratype males in Ball collection. Paratype male and female in author's collection.

Ballana tiaja n. sp.

Resembling *vetula* in general appearance and coloration but larger and with distinct genitalia. Length 5.5–6 mm.

Vertex broadly rounded, one and one-half times as wide between eyes at base as median length, margin thick bluntly angled with front.

Color: White to pale yellow, disc of pronotum and elytra appearing gray.

Genitalia: Female last ventral segment narrowed to bluntly rounded lateral angles between which the posterior margin is slightly excavated and the margin is slightly convexly rounded. Male plates about as long as combined basal width, broadly triangular, sides slightly concave at middle, apices broad, blunt, rounded, not reaching to posterior spines.

Described from a series of two female and three male specimens collected at Tia Juana, Mexico, August 2, 1912, and one male, same locality, June 15, 1908, by Dr. E. D. Ball. Holotype male, allotype female and male paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana recurvata n. sp.

Resembling *vastula* in form and appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex sharply angled, apex blunt, bluntly angled with front, about one-fourth wider between eyes than length at middle.

Color: Vertex and scutellum yellowish, pronotum dull green, elytra dull greenish, apical portion posterior to cross veins brownish.

Genitalia: Female last ventral segment roundedly produced, central third forming a slightly sunken almost truncated lobe. Male plates rather long, about one-fourth longer than combined width at base, gradually sloping to bluntly pointed apices which extend just to apex of anal tube.

Described from four female and two male specimens collected from carrots, turnips, and beans at Boise, Idaho, July 11, 1930, (DeLong); five males and three females collected at Santa Margarita, California, June 23, 1931, (Ball); and four females and two males from Medford, Oregon, June 26, 1934, (Ball). Holotype male, allotype female (Boise, Idaho) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana bifida n. sp.

Resembling *titusi* but with vertex more bluntly angled and with distinct genital characters. Length 4.5 mm.

Vertex bluntly angled, about one-fourth wider between eyes at base than length at middle.

Color: Vertex, pronotum and scutellum yellowish, disc of pronotum dark green. Elytra dark green, venation pale, apices subhyaline.

Genitalia: Female last ventral segment with lateral margins rounded to form outer rounded lobes of posterior margin between which the central third is broadly shallowly emarginate. Male plates long and narrow, a little longer than combined width at base, sides slightly concave, apices bluntly pointed reaching the posterior spines.

Described from a series of four male and seven female specimens collected at Craters of the Moon, Idaho, June 29, 1930, Idaho City, Idaho, July 13, 1930, and Murtaugh, Idaho, June 21, 1930, by the author; Holotype male and allotype female (both from Craters of the Moon) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana dira n. sp.

Resembling *attenuata* in general form but pale in color and with distinct genitalia. Length 5.5–6 mm.

Vertex rather sharply angled, one-third wider between eyes at base than median length, rather sharply angled with front.

Color: Vertex and scutellum yellowish, pronotum and elytra rather pale dull green.

Genitalia: Female last ventral segment sloping from base to narrowed posterior margin which is rather squarely, broadly and shallowly excavated on median half, base of excavation black margined. Male plates as long as combined width at base, sides convexly rounded, apices broad, bluntly rounded, almost reaching to posterior spines.

Described from a series of two male and one female specimens collected at Tucson, Arizona, April 10, 1931; two male and two female specimens at Tinajas Altas, Ariz., March 27, 1932, and three male and one female specimens at Ajo Mts., Ariz., April 21, 1930, all by Dr. E. D. Ball. Holotype male, allotype female (Tucson, Ariz.), and male and female paratypes in Ball collection. Male and female paratypes in collection of the author.

Ballana cuna n. sp.

Resembling *ortha* in form and general appearance but with head even more blunt and with distinct genitalia. Length 5–5.5 mm.

Vertex very blunt, almost rounded in front, almost twice as wide between eyes as length at middle, margin of vertex thick.

Color: Vertex yellow, pronotum, scutellum and elytra green, tinged with yellow, veins of elytra paler.

Genitalia: Female last ventral segment with lateral margins sloping and posterior margin narrowed, sinuate, a narrow shallow U-shaped notch at center. Male plates as long as combined width at base, sides slightly convexly rounded, apices bluntly pointed, not reaching to posterior spines.

Described from a series of four male and four female specimens collected at Weed, California, June 22, 1934, by Dr. E. D. Ball. Holotype male, allotype female and male and female paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana seca n. sp.

Resembling *cuna* in form and general appearance but with distinct genitalia. Length 5.5–6 mm.

Vertex broadly rounded, almost twice as wide between eyes as median length. Margin thick, rounded to front.

Vertex and scutellum yellowish, pronotum and elytra dull green, veins pale.

Genitalia: Female last ventral segment narrowed to posterior margin which is broadly rather squarely excavated on median half. Male plates not quite as long as combined basal width, sides slightly concave, apices rather broad, bluntly pointed, not reaching posterior spines by about one-third their length.

Described from a series of four male and four female specimens collected at Lebec, California, June 28, 1934, by E. D. Ball. Holotype male, allotype female and male and female paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana mana n. sp.

Resembling *seca* in form and general appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex broadly rounded, almost twice as long between eyes at base as median length. Margin thick, rounded to front.

Color: Vertex and scutellum dull yellow, pronotum and elytra dull greenish.

Genitalia: Female last ventral segment with side margins sloping and narrowed to posterior margin which is broadly, squarely emarginate one-fourth the distance to base. Male plates short, not as long as combined basal width, sides convexly rounded, apices rather broad, bluntly rounded, not reaching posterior spines by at least half their length.

Described from two male and one female specimens collected at Mojave, California, July 1, 1931, by E. D. Ball. Holotype male and allotype female in Ball collection. Male paratype in author's collection.

Ballana bicornis n. sp.

Resembling *atridorsum* in general appearance, bright green with distinct genitalia. Length 5.5 mm.

Vertex broad, bluntly angled, about one-third wider between eyes than length at middle.

Color: Vertex, pronotum and scutellum yellow, disc of pronotum green. Elytra bright green veins paler.

Genitalia: Female last ventral segment narrowed to apical margin which is broadly roundedly, almost squarely excavated one-fifth the distance to base. Male plates about equal in length to combined basal width, side margins slightly convexly rounded, apices bluntly pointed, not reaching posterior spines.

Described from two male and one female specimens from Logan Mt., Utah, July 22, 1930, (DeLong); one female, Sardine Canyon, Utah, July 28, 1930, (DeLong); one female, Nampa, Idaho, July 12, 1930, (DeLong); five male and five female specimens from Santa Margarita, California, June 23, 1931, (Ball); a male and a female from Yosemite, California, June 21, 1931, (Ball). Holotype male, allotype female (Logan Mt., Utah) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana velosa n. sp.

Resembling *bicornis* in general appearance but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, not quite twice as wide between eyes as length at middle; margin thick.

Color: Vertex pronotum and scutellum pale yellow, disc of pronotum dark green. Elytra dark green, apices subhyaline.

Male plates slightly longer than basal width, side margins slightly, convexly rounded, apices bluntly rounded, not reaching posterior spines by about one-fourth their length.

Described from two male specimens collected at Murtaugh, Idaho, June 21, 1930, (DeLong). Holotype male and paratype male in author's collection.

Ballana antlera n. sp.

Resembling *velosa* in form and general appearance but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, not quite twice as wide between eyes as length at middle. Margin thick.

Vertex, scutellum and anterior portion of pronotum yellow, part of pronotum and elytra dull green.

Genitalia: Female last ventral segment with lateral margins strongly convexly rounding to form outer rounded lobes between which the posterior margin is broadly excavated about one-fourth the distance to the base. Male plates about as long as combined basal width, sides almost straight, apices broad and bluntly rounded, almost one-third their basal width, not reaching posterior spines by about one-fourth their length.

Described from a pair of specimens collected at Murtaugh, Idaho, June 21, 1930, by the author. Male holotype and female allotype in author's collection.

Ballana aris n. sp.

Resembling *velosa* in form and general appearance but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, not quite as wide between eyes at base as length at middle. Margin thick.

Color: Dull green, vertex and scutellum yellowish.

Genitalia: Female last ventral segment with lateral margins obliquely sloping to form bluntly rounded lobes between which the posterior margin is broadly excavated about one fourth the distance to base. Male plates not quite as long as combined basal width, sides almost straight, apices bluntly pointed, not reaching to posterior spines.

Described from a male specimen from Rosette, Utah, June 28, 1929, Knowlton; and a pair of specimens from Kelsaw Canyon, Idaho, collected September 2, 1925, Haegele. Holotype male, allotype female (Kelsaw Canyon, Idaho) and female paratype in author's collection.

Ballana dena n. sp.

In form and general appearance resembling *velosa* but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, not quite twice as wide between eyes at base as length at middle.

Color: Dull grayish green, unmarked.

Genitalia: Male plates not as long as combined width at base, apices more than two-thirds the width at base, blunt, broadly rounded, almost truncate.

Described from a single male specimen from Santa Barbara, California, May, 1918. Holotype male in author's collection.

Ballana calipera n. sp.

Resembling *velosa* in form and general appearance but with distinct genitalia. Length 6 mm.

Vertex bluntly angled, not quite twice as wide between eyes at base as length at middle.

Color: Vertex pronotum and scutellum yellow, disc of pronotum and elytra dark green.

Genitalia: Female last ventral segment with lateral margins strongly convexly rounding to posterior margin which has a rounded outer lobe either side of a central half which is excavated one-fifth the distance to the base, the central portion of which is gently convexly rounded. Male plates about as long as combined basal width, apices blunt, rounded, not reaching posterior spines by about one-fourth their length.

Described from five male and six female specimens collected at Logan Canyon, Utah, July 24, 1930, (DeLong); one female and three male specimens, Tahoe National Park, California, August 6, 1930, (DeLong); four males, Craters of the Moon, Idaho, June 29, 1930, (DeLong); three female specimens, Colfax, California, August 7, 1930; two males, Glendale, Nevada, May 5, 1929, (Fox); one male, Overton, Nevada, June 6, 1930, (Davis); one male, St. George, Utah, June 4, 1930, (Davis); and four male and three female specimens, Medford, Oregon, June 26, 1934, (Ball). Holotype male and allotype female (Logan Canyon, Utah) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana chelata n. sp.

Resembling *titusi* in form and appearance but with distinct genitalia. Length 5 mm.

Vertex produced and angled, about one-fifth wider between eyes than length at middle, vertex bluntly angled with front.

Color: Vertex yellow, pronotum, scutellum and elytra green, veins paler, apex subhyaline.

Genitalia: Female last ventral segment rather long, lateral margins strongly convexly rounded to produce outer lobes on last ventral segment between which the central third is slightly excavated, the basal margin of excavation slightly convexly rounded. Male plates a little longer than combined basal width, sides almost straight, apices bluntly pointed, not reaching posterior spines.

Described from two female and one male specimens collected at Pacific Grove, California, Aug. 17, 1930, (DeLong); and two male and three female specimens from Muir Woods, California, June 17, 1934, (Ball). Holotype male and allotype female (Pacific Grove, California) and female paratype in author's collection. Male and female paratype' in Ball collection.

Ballana callida n. sp.

Resembling *chelata* in form and general appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex strongly produced and angled, about one-fifth wider between eyes than length at middle and acutely angled with face.

Color: Vertex yellowish, pronotum, scutellum and elytra green tinged with yellow. Elytra with apical cells black.

Genitalia: Female last ventral segment with side margins sloping, narrowed to posterior margin which is broadly squarely and rather shallowly notched two-thirds its width. Male plates about as long as combined width at base, sides straight, apices bluntly pointed, not reaching to posterior spines.

Described from two male and two female specimens collected at Riverside, California, June 13, 1931, and a male from Alpine, California, collected July 5, 1931, all by Dr. E. D. Ball. Holotype male, allotype female and male paratype in Ball collection. Male and female paratypes in collection of the author.

Ballana repa n. sp.

Resembling *angula* in form and general appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex produced but broadly rounded, twice as wide between eyes at base as median length. Margin thick rounded to front.

Color: Yellowish, tinged with green on pronotum, scutellum and elytra.

Genitalia: Female last ventral segment convexly roundedly produced from base to form a narrow posterior margin about half the width of segment which is truncate. Male plates a little longer than combined width at base, side margins concave at middle, apices bluntly rounded, not quite reaching posterior spines.

Described from a male and three female specimens collected at Yuma, Ariz., April 14, 1933, by E. D. Ball. Holotype male, allotype female and female paratype in Ball collection. Female paratype in author's collection.

Ballana latula n. sp.

Female resembling *vapida*, male greenish and with distinct genitalia. Length 6.5 mm.

Vertex broadly, very bluntly angled, twice as wide between eyes at base as median length, sharply angled with front.

Color: Female pale brown on vertex and scutellum. Pronotum and elytra dark brown flecked with yellow, apical veins yellow. Male vertex yellowish, pronotum, scutellum and elytra bright green, apices of elytra smoky.

Genitalia: Female last ventral segment broken but appearing truncate or slightly emarginate. Male plates one-fourth longer than combined width at base, convexly rounded apical fourth more rapidly tapered to form bluntly pointed tips which are produced about as long as anal tubes.

Described from one female and three male specimens collected at Weed, California, June 27, 1934, by E. D. Ball. Holotype male, allotype female and male paratype in Ball collection. Male paratype in author's collection.

Ballana paridens n. sp.

Resembling *vapida* in appearance and coloration but with distinct genitalia. Length 6 mm.

Vertex produced but bluntly angled, about one and two-thirds times as wide between eyes as length at middle.

Color: Brownish tinged with yellow, face with a series of conspicuous arcs broken at middle. Vertex pale brownish, reflexed arcs of face usually visible on margin from above. A pair of faint spots just above apex and a longitudinal stripe on disc either side, darker. Pronotum dark brown, paler on anterior margin. Elytra dark brown irrorate with yellow, veins yellow.

Genitalia: Female last ventral segment narrowed at base, lateral margins produced to posterior margin which is broadly, rather shallowly but squarely excavated and heavily black margined. Male plates about as long as combined basal width, sides concavely rounded. Apices rather broad, rounded, not reaching posterior spines by more than one-third their length.

Described from a series of four male and four female specimens collected at Pine Valley, California, July 6, 1931, by Dr. E. D. Ball. Holotype male, allotype female and male and female paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana latera n. sp.

In form and appearance resembling *dissimilata* but with distinct genitalia. Length 6.5 mm.

Vertex bluntly angled, more than one and one-half times as wide between eyes at base as median length. Margin acutely angled with front.

Color: Vertex tawny, ocelli black, recurved arcs from front visible from above on margin of vertex. Pronotum, scutellum and elytra dull greenish, washed with yellow, veins yellowish.

Male plates about as long as combined basal width, triangular, sides slightly concave at middle, apices bluntly pointed, not reaching posterior spines by at least one-third their length.

Described from a single male specimen collected at Santa Margarita, California, June 25, 1909, by E. D. Ball. Holotype male in Ball collection.

Ballana arma n. sp.

In coloration resembling *dissimilata* but smaller with blunter vertex and with distinct genitalia. Length 6.5–7 mm.

Vertex broad, scarcely produced, bluntly angled, about one-half wider between eyes at base than length at middle.

Color: Male green, female brown. In both sexes the vertex is yellowish with reflexed arcs of face visible on margin from above. In male, pronotum green with yellowish anterior margin, elytra green with paler veins. Female pronotum brown with paler margin, elytra dark brown with paler veins.

Genitalia: Female last ventral segment only two-thirds as wide at base as previous segment, gradually narrowed to posterior margin which is broadly rather shallowly excavated between prominent angles. Male plates not quite as long as combined basal width, sides concavely rounded at middle, apices rather broad, bluntly rounded, not reaching posterior spines by half their length.

Described from two male and two female specimens collected at Yarnell Heights, Arizona, June 21, 1935, by Dr. E. D. Ball. Male holotype and female allotype in Ball collection. Male and female paratypes in author's collection.

BOOK NOTICES

The Origin of Higher Categories in Cynips

This scientific volume is a taxonomic study of 70 new species belonging to the genus Cynips. It is the second volume published by the author on the genus, the first being published in 1930. Most of the new species are from Guatemala and Mexico. Additional information concerning certain species mentioned in the first volume has been added to the second volume. An excellent evolutionary discussion precedes the descriptions. The author has taken the higher categories which were established for the diverging ends of the evolutionary lines in the United States and united them with the existing Mexican species and thus has endeavored to throw light on the origin of higher categories in general. The discussion begins with current concepts of higher categories, followed by modern phylogenetics and the nature and origin of higher categories in Cynips. The author shows that these complexes of species or higher categories are artificial conventions useful for cataloguing biologic data, but are hardly real either in manner of origin or in their intrinsic qualities. He defines higher categories as arbitrarily limited groups of related species in a phylogenetic chain. The content of the volume indicates years of collecting in the field and intensive thought and study of material in the laboratory. Such studies are greatly needed. A bibliography and index are included.—R. H. DAVIDSON.

The Origin of Higher Categories in Cynips, by Alfred C. Kinsey. 334 pp., 172 figs. Bloomington, Indiana University Publications, Science Series No. 242. (Sold by Indiana University Bookstore.) 1936. $2.50.

Photography

"New Ways in Photography" reads like a novel. The book creates in the mind of the reader an enthusiasm for photography as a hobby. A great deal of information on how to produce unusual pictures may be found in the various chapters. The titles of the chapters indicate the refreshing style of the text matter. These are: "Candid" camera capers, The good side of bad weather, After the sun goes down, "Flash, you're it," The family heirs, Hails and farewells, As the worm and bird see it, Remote control, Transparencies, Photomurals and photowallpaper, Effects with filters, Two simple three-color-processes, Photographic multiplication, The long and short of it, "Jest Foolin," Table top trickery, Potpourri, How the professional gets around it, The mending basket, Your own salon, Now it's up to you, Formulary, Index.

This book is not the usual type of reference book nor is it an orderly compendium of methods and facts, yet it contains much unusual and unique information for the amateur who takes his hobby seriously. It will make a worthwhile addition to a personal library.—A. PETERSON.

New Ways in Photography, by Jacob Deschin. 307 pp., illustrated. New York, McGraw-Hill Book Co., 1936. $2.75.

A New General Zoölogy

In his new (1937) text in the field of general zoölogy Professor Lindsey offers something which is different in the way of organization and treatment. The arrangement is not based upon the usual one of taxonomic sequence but upon generalized areas of subject matter. The book is divided into six parts, as follows:

Part I, "The Foundations of Life," proceeds from a historic approach to a consideration of the general character and organization of living matter. Part II, "The Organization and Classification of Animals," is largely the usual descriptive treatment of the phyla in evolutionary order and supposed relationship. Part III, "The Maintenance of the Individual," deals with metabolic processes using examples and illustrations from all parts of the animal kingdom. The relations of organisms with their environment and the interchanges of materials are especially emphasized. Part IV, "The Maintenance of the Species," covers reproduction in general as well as embryology and heredity. Part V, "Problems of Origin," includes the theories and evidences of evolution. Part VI, "Biology and Human Life," gives special attention to the origin of man, the development of his cultures and the consideration of his social problems in the light of biology. This treatment is unusual and much to be commended.

Each of these subject groupings is treated in a comprehensive scholarly fashion sufficient to satisfy the requirements of an exacting general course. The text is quite readable even though a little heavy with technical terminology. The numerous illustrations are unusually good and appropriate. In some instances the author arouses curiosity by general statements without satisfying the curiosity by concrete examples. This may not be a fault if it stimulates the student to seek further knowledge from additional sources. There is also the prevalent tendency toward teleological explanation, but there is not enough of this to detract materially from the accuracy of the factual statements.

The book is good and deserves consideration wherever a course in general college zoölogy is offered. There is a fairly extensive glossary, a good index and a list of one hundred reference books with names of publishers and dates and a brief comment upon the contents of each book. The volume is convenient in size, and pleasingly as well as substantially bound.—D. F. MILLER.

The Science of Animal Life, by Arthur Ward Lindsey. xi+656 pp. New York, Harcourt, Brace and Co., 1937. $3.75.

Psychology

Writing from the point of view of a self-styled "old fashioned psychologist" and consequently holding that a "study of consciousness comprises a very important part of the field of psychological study," the author has produced a text book consisting of five parts, covering twenty-two chapters. Introducing his point of view with a definition of psychology and a brief history of the field, the author launches at once, in the second part of the book, into a discussion of the "simpler conscious processes"—more correctly designated, perhaps, as the sense fields. In logical order "complex conscious processes" follow in the third part. It is interesting to note that the material embodied under the simpler and complex conscious processes absorbs approximately fifty per cent of the total content of Fernberger's book.

Part IV, assigned the general and somewhat inclusive title "Reaction," contains a heterogeneous series of chapters on the nervous system, reflex, instinct, emotion, volition, and habit. Finally, in Part V, the "integrated organism" has its moment, wherein drive and motivation, individual differences, and integrated personality receive a sketchy treatment.

The author has apparently striven for a logical order of presentation which is altogether artificial and which adds nothing to the clarity or comprehensibility of his position. For instance, it seems of questionable validity to include **thinking** under **complex conscious processes** and **habit** under **reaction.** Further, it is difficult to understand why **learning** has been ignored as a special category. Insignificant attention has been devoted to social behavior, child development, and more recent aspects of measurement. Topics which do receive major emphasis are not far removed from the classical laboratory. By and large, if the objective of psychology is to be that of allegedly "pure science," then likely Fernberger's

work fulfills most requirements. If, however, pragmatic emphasis is the order of the day in the development of scientific psychology, then the author's book has not moved a very great distance from the strictly conventional approach of the older school.—M. A. DUREA.

Elementary General Psychology, by Samuel W. Fernberger. xxii+445 pp. Baltimore, the Williams and Wilkins Co., 1936. $3.00.

Raising Invertebrates

For a number of years biological scientists have wished for a publication that would bring together the better known methods on how to rear various invertebrate animals. In large measure this wish has been fulfilled in the new book entitled "Culture Methods for Invertebrate Animals." The committee in charge of this publication, J. G. Needham (Chairman), P. W. Galtsoff, F. E. Lutz, P. S. Welch, and its secretary Mary E. Davis, have assembled a valuable series of original articles and compilations on collecting and rearing methods for invertebrate animals. The committee is to be congratulated on completing its job in such an effective manner.

In this book an attempt is made to include rearing information on all groups (usually families) of invertebrates, by presenting detailed information on one or more representatives in each group. Naturally the Arthropods occupy the greater portion of the book, covering over 300 pages. The aquatic species among the various groups are discussed and treated extensively and intensively. Among the insects a number of important groups and species are omitted. In some instances, however, the information presented on closely related groups will be of assistance. A more extensive presentation of detailed figures of the equipment employed in rearing would have added considerably to the value of the book.

A work of this character should stimulate investigators to make careful and detailed reports on the methods they pursue in rearing invertebrates. Undoubtedly many valuable methods have not been published and it is hoped that they will make their appearance in the near future, so they may be included in future revisions. This book will make a valuable addition to any private or public biological library.—A. PETERSON.

Culture Methods for Invertebrate Animals, by a committee of American Zoologists from Section F. of A. A. A. S. xxxii+590 pp., 84 figs. Ithaca, New York, Comstock Publishing Company, 1937. $4.00.

Biological Control

The author of the first book in the English language on biological control of insects has compiled an interesting introduction to this subject. This volume provides a general text and much valuable information for beginning students and for those desiring general information.

For advanced students and investigators in biological control the book does not fulfill the decided need for a source book of knowledge. A volume (or volumes) of this nature can only be prepared by one or more investigators who have had many years of research and practical experience and have a broad viewpoint of the entire subject. One should not expect this volume to be a thorough and comprehensive treatise for the author has had very little practical experience in biological control. Also, so far as is known, the author has not published any original research in this field.

Many investigators in the field of biological control will not agree with several important definitions presented in the book. The chapters (6 and 7) on parasitic Diptera and Hymenoptera, are much too brief in scope and content to be of very great value to students or investigators. One of the unfortunate features of the book is the lack of cross references in the text portion. Most of the thoughts and ideas expressed in the various chapters have been stated by the investigators listed in the references at the end of the book. The author should have indicated the source of these ideas, especially where the same phraseology is used. A short glossary and a list of references occur at the end of the book.—A. PETERSON.

The Biological Control of Insects, by H. L. Sweetman. viii+454 pp. Ithaca, the Comstock Publishing Co., 1936. $3.75.